

Resumen por el autor, H. D. Senior.

El desarrollo de la arteria femoral humana. Una corrección.

El objeto de este trabajo es corregir una descripción errónea sobre el desarrollo de la arteria femoral, publicada por el autor en el *American Journal of Anatomy*, vol. 25, núm. 1, pág. 55. El error se debe a una interpretación incorrecta del material imperfectamente fijado sobre el cual se basó la descripción mencionada. Consistió el error en no reconocer la presencia del plexo vascular que precede inmediatamente a la aparición de la arteria femoral y sus primeras ramificaciones. La red femoral, como se llama al plexo completamente formado, está reunida con la arteria ilíaca externa del embrión por medio de dos ramas (las arterias recurrentes femorales). Más distalmente, está reunida con las ramas del ramo comunicante superior, una rama recurrente de la arteria axis, que se origina al nivel del hiato tendinoso. Las ramas recurrentes femorales, la parte de la red femoral que vierte sangre en el ramo comunicante superior y el mismo ramo comunicante se reúnen para formar la arteria femoral. El resto de la red femoral se convierte en arterias, capilares y venas. Su componente arterial se convierte en las ramas que están reunidas con la arteria femoral en el momento de su primera aparición. Los componentes capilar y venoso se transforman en los canales para la distribución y vuelta de la sangre que corre por ellos. La descripción originaria del desarrollo de las ramas de la arteria femoral, que aparecen en estados ulteriores, parece ser substancialmente correcta. La arteria circunfleja femoral media se reconoce primeramente en el estado de 24 mm., poco más o menos.

Translation by José F. Nonidez
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THE DEVELOPMENT OF THE HUMAN FEMORAL ARTERY, A CORRECTION

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FOUR FIGURES

A recent paper upon the development of the arteries of the human lower extremity contains a record of certain conclusions regarding the development of the femoral artery which have since proved to be founded upon an error of observation.¹

An examination of the literature relating to the arterial anomalies of the human thigh reveals the fact that only two general classes of variation of the adult femoral artery have been recorded. These are the imperfection of development which occurs in association with persistence of the embryonic a. ischiadica, and the anomaly of partial reduplication.

Partial reduplication of the femoral trunk occurs with relative frequency and has assumed a variety of forms which do not require particular notice here. It may be said, however, that none of the forms in question can legitimately be interpreted as having arisen through modification of the process of development which was described in the paper cited above. In recognition of the value of arterial anomalies as presenting a natural means of controlling the results of embryological study, the development of the femoral artery has been submitted to further examination.

The search for fresh material in suitable stages of development has involved the examination of a relatively large amount of

¹ The Development of the Arteries of the Human Lower Extremity, H. D. Senior, *Am. Jour. Anat.*, vol. 25, pp. 67 and 88, also figs. 3 and 9C. (Unfortunately, the mistake has been repeated in connection with the anomaly of a. saphena magna in *An Interpretation of the Arterial Anomalies of the Human Leg and Foot*, by the same author, *Jour. Anat.*, Cambridge, vol. 53, p. 142).

material. For the use of the embryos so kindly placed at my disposal, I am greatly indebted to the kindness of Profs. B. F. Kingsbury, F. T. Lewis, and G. L. Streeter. Two embryos have been found, Carnegie Embryo no. 353 and Kingsbury Embryo no. 26, which clearly demonstrate the nature of the erroneous conception I originally entertained regarding the development of the femoral artery. They are in an excellent state of preservation and represent a stage of development which agrees, more or less closely, with that of the 12-mm. embryo (Minnesota H. 14²). A description of the arteries of the right lower extremity of the latter embryo appeared in the paper previously cited.³

Figures 1 and 2 represent a reconstruction of the arterial apparatus of the right thigh of Carnegie Embryo no. 353 and of Minnesota Embryo H. 14, respectively, as seen from the preaxial aspect. The nature of my former error will become evident upon making a comparison between them. Two more or less completely separate arterial channels, which are seen in figure 1 to pass from the a. iliaca externa into the thigh, break up into an extensive plexus of capillaries. The plexus, which is represented somewhat diagrammatically, spreads throughout the tissues of the thigh, but is more dense in the periskeletal region than elsewhere. It becomes somewhat widely scattered and more loosely meshed as it passes distally and is lost in the region immediately beyond the knee. A large recurrent branch which arises from the axial artery a short distance proximally to the knee-joint divides into branches which soon become lost among the other elements of the plexus. The plexus shown in figure 1 is entirely absent from the reconstruction from which figure 2 was drawn. Apart from this omission, the arteries which appear in the latter figure seem to have been accurately represented. Whether the difference in the arrangement of the terminal branches of the a. iliaca externa of the two figures is due to individual variation or depends upon a difference in the ages of the embryos represented, has not been determined. A

² Through an unfortunate mistake, this embryo was referred to in the original paper as Minnesota Embryo H. 16.

³ See page 67 and figures 3 and 9C. The latter figure is reproduced here as figure 2.

review of the data, derived from these and other embryos, which have a bearing upon the question will be found on page 278.

The drainage of the femoral plexus (fig. 1, *rete femorale*) is accomplished in two ways. A portion of the blood traversing its wide capillary channels passes into the distal part of the axial artery through the recurrent branch of the latter vessel, the remainder is drained by veins in the usual manner. The

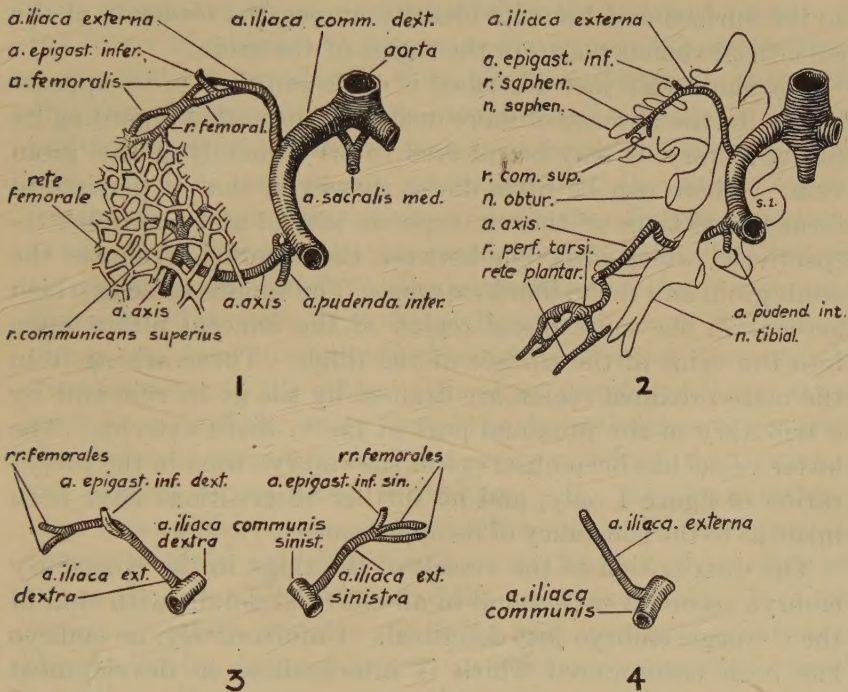


Fig. 1 The arteries and capillaries of the right thigh, Carnegie Embryo no. 353.

Fig. 2 A reproduction of figure 9C from *The Development of the Arteries of the Human Lower Extremity*. The femoral plexus shown in the preceding figure is omitted. The labeling is incorrect.

Fig. 3 The right and left external iliac arteries and their branches, Harvard Embryo no. 816.

Fig. 4 The right external iliac artery, Harvard Embryo no. 1006.

The figures represent the cephalic (embryonic preaxial, adult medial) aspect of reconstructions $\times 20$ diams. The reconstruction used for figure 4 was made by the graphic method, the others by means of wax plates. The lengths of the embryos used are noted in the text.

v. iliaca externa is placed upon the dorsal aspect of the corresponding artery and ends distally by bifurcating into the v. epigastrica inferior and a vein which passes toward the thigh. The latter vessel passes through the more proximal of the two intervals between the two femoral branches of the a. iliaca externa which are shown in the figure. After accompanying the femoral branches for a short distance, the vein passes directly to the surface and loses its identity among the elements of the superficial venous plexus of the region of the groin.

The short vein just described is quite constant in its appearance. In the absence of more definite information regarding its future history, it may be referred to provisionally as the 'groin vein.' There can be little doubt, however, that it persists to form the sections of the vv. saphena magna and femoralis, respectively, which intervene between the superficial veins of the adult groin and the v. iliaca externa. The venous radicles which arise from the more distal region of the femoral plexus open into the veins of the surface of the thigh. Those arising from the more proximal region are drained by the groin vein and by a tributary of the proximal part of the v. iliaca externa. The latter vessel has been observed in the embryo used in the preparation of figure 1 only, and no further observations have been made as to the constancy of its appearance.

The distribution of the vessels of the thigh in the Kingsbury embryo seems to correspond in all essential details with that of the Carnegie embryo just described. Unfortunately, no embryo has been encountered which is intermediate in development between the stage represented by these two embryos and that in which the femoral artery is represented by a single continuous channel. It has become necessary, therefore, to endeavor to form a just estimate of the relation between the vascular apparatus of the thigh as shown in figure 1 and the trunk and earlier branches of the femoral artery as they appear at the stage of 14 mm.⁴ At the latter stage of development the a. femoralis

⁴ The distribution of the arteries of the right thigh of Cornell Embryo no. 5, which measures 14 mm., is indicated in figures 4 and 9d of the paper previously cited. The vascular conditions in the thigh of that embryo are duplicated, in all essential respects, in a Carnegie Embryo of the same length (no. 940).

presents itself in the form of a single trunk which gives separate origin to the *a. circumflexa femoris lateralis* and to the *r. saphenus* and *r. musculoarticularis* of the *a. genu suprema*. Three other branches arise from the medial side of the vessel which are not recognizable as corresponding to any of the branches of the adult femoral artery.⁵ They lead to an extensive capillary plexus which ramifies mainly in the periskeletal region of the thigh. This plexus, which no doubt furnishes the nutrient arteries of the femur in addition to supplying the developing musculature is eventually taken over by the *a. profunda femoris*. It is probable that the branches of the *a. femoralis* of the stage of 14 mm. and the capillary plexus in which they terminate together represent a further stage in the development of the portion of the femoral plexus which was originally drained by the venous system. It also seems probable that the proximal part of the adult femoral artery is formed either by the coalescence of the two femoral channels which pass from the *a. iliaca externa* to the femoral plexus (fig. 1) or through the persistence of one of them and the disappearance of the other. The short distal and larger intermediate parts of the artery seem to be derived, respectively, from the recurrent branch of the axial artery and from the portion of the femoral plexus which is drained by it. Besides forming a very short distal section of the adult *a. femoralis*, the recurrent branch of the *a. axis* provides the actual means of junction between the two major arteries of the embryonic limb. It is this vessel, therefore, and not one of the more proximal elements of the developing femoral artery, as I formerly supposed, which constitutes the true *ramus communicans superius*.

Through the courtesy of Prof. C. M. Jackson, I have had an opportunity of reexamining the conditions existing in the 12-mm. embryo used in the preparation of figure 2. In the light of experience gained from the study of other embryos, I find that the portions of the bifurcated femoral channel and of the *r. communicans superius*, which are filled with corpuscles, are the only vessels of the developing arterial system of the thigh which have been reconstructed. The other vessels are very difficult to iden-

⁵ Op. cit., pp. 72 and 76.

tify in the specimen owing to the macerated condition of their lining endothelium. The elements of the femoral plexus appear in the sections as a number of indefinitely circumscribed spaces in which an occasional corpuscle can be found. I originally confused them with the other unlined spaces which are plentifully scattered throughout the partially macerated tissue.

It is clear from the conditions encountered in the embryo used in the preparation of figure 1 that the formation of the *a. femoralis* is preceded by the presence of a perfectly definite and reconstructable plexus of capillaries. This is connected proximally with the femoral branches of the *a. iliaca externa*, which forms part of an arteriovenous loop, and distally with the *r. communicans superius*, which has no companion vein. Such a plexus might well be regarded as having originated through the coalescence of two subsidiary plexuses, perhaps of unequal size, which had spread from the arterial branches at either end of the thigh. The evidence presented by younger embryos, however, does not admit of such an interpretation.

Figure 3 represents a reconstruction of the right and left external iliac arteries of Harvard Embryo no. 816. The three terminal branches, which are arranged somewhat differently upon the two sides, represent the inferior epigastric artery and two femoral channels. The reconstruction shown in figure 4 represents the right external iliac artery at a stage slightly earlier than that at which its branches appear. It is from Harvard Embryo no. 1006, which is 11.5 mm. in length. Neither the *a. iliaca externa* of this embryo nor the branches of that artery which appear in figure 3 are traceable into a definite femoral plexus. The vessels shown in both figures appear to end quite abruptly. It cannot be said, however, that the thigh of either embryo is entirely free from capillaries.

I have endeavored, with inconclusive results, to trace the genesis of the very clearly defined plexus which immediately precedes the appearance of the *a. femoralis* by an examination of several embryos measuring from 6 to 12 mm. It has been my experience that unmistakable evidence of the presence of a capillary plexus may be detected in the thigh and in all other

parts of the lower limb in well-preserved embryos of any stage of development. The existence of a plexus in the earlier stages can be inferred from the occurrence of small groups of corpuscles which are scattered throughout the sections of uninjected material. I have been quite unable to determine the nature of the connection which presumably exists in the stage of development represented by figure 4, between the femoral plexus and the *a. iliaca externa* and the *r. communicans superius*, respectively. Some elements of the more distal part of the plexus seem, at the stage represented by figure 3, to be connected with the *r. communicans superius*. I have not been able to detect the existence of a definite connection, however, between the plexus of that stage and the *rr. femorales* of the *a. iliaca externa*.

The conditions met with in the stage represented by figure 1 differ very strikingly from those encountered in the earlier stages of development. The elements of the greater part of the plexus are almost as large as the *rr. femorales*, and their connections with the major arterial and venous channels of the thigh can be easily traced. It is not difficult to make a reconstruction from an embryo of this stage which furnishes, in all probability, a fairly accurate representation of the entire vascular apparatus of the thigh. I know of only one vascular plexus occurring in the developing lower extremity which at all resembles the wide-channelled predecessor of the femoral artery and its branches. It is the arterial plexus which precedes the appearance of the *a. dorsalis pedis*, the *r. plantaris profundus*, the *arcus plantaris*, and the larger branches of those vessels. To denote the dorsal and plantar sections of the latter plexus, respectively, I have used the terms *rete dorsale* and *plantare*, respectively. The term '*rete femorale*' may well, I think, be applied to the corresponding plexus of the thigh; figure 1 has been labeled accordingly.

I have avoided the application of the term *plexus femoralis* to the later phase of vascular plexus of the thigh because a careful examination of uninjected material has yielded so little information regarding its relation to the femoral portion of the more intangible plexus of earlier stages of development. There is no reason to suppose that the process involved in the development

of the femoral artery differs materially in the different orders of the mammalian series. If it should prove to be substantially similar in the embryo of any form of which a relatively large series of injections could be made, the earlier history of the so-called femoral rete could be investigated with a better prospect of success. The tentative use of the term 'rete' is suggested in the meanwhile without intending to cast doubt upon the intimacy of the relation between the femoral plexus of the earlier and later stages of development. The distinction of terms is used primarily on account of failure to determine the nature of the relation which probably exists between them.

One feature of the developmental history of the femoral artery remains to be noted. It seems to find a reflection in the variations of form which the femoral arterial channel has assumed in the recorded instances of the anomaly of partial bifurcation of the adult artery. The feature referred to is the difference in the arrangement of the terminal branches of the *a. iliaca externa* which has been observed in the embryos studied. The three branches of the left external iliac artery shown in figure 3 arise independently of one another. Upon the right side of the same embryo the *a. epigastrica inferior* arises independently, while the two femoral branches have a common stem of origin. The latter arrangement is repeated on the right side of the Kingsbury embryo and on both sides of the embryo used in the preparation of figure 2. In the embryo used for figure 1, one of the femoral branches arises independently from the *a. iliaca externa*, while the other arises in common with the *a. epigastrica inferior*.

Whether the terminal branching of the *a. iliaca externa* is subject to an inherent tendency toward variability or whether the observed variation depends upon slight differences in the relative ages of the embryos examined, it is difficult to say. The Carnegie embryo (no. 353) used for figure 1 measured 11 mm. before cutting, it is obviously more advanced in development than the Harvard embryo (no. 816) used for figure 3 which measured 12 mm. The Kingsbury embryo (no. 26) measured 13 mm., although it appears to be in approximately the same stage of development as Carnegie no. 353. The Minnesota

embryo is not sufficiently well preserved to permit of a very close comparison between the condition of its vascular system and that of the Carnegie and Kingsbury embryos. The more advanced development of its femur suggests, however, that it is somewhat older than either of the other two; it measured 12 mm. before cutting. That the measurement of an embryo, either before or after fixation, does not always provide an accurate indication of its relative stage of development is, of course, well known.

The portion of the a. profunda femoris which forms the common stem of origin of the aa. perforantes arises shortly before the stage of 22 mm. The a. circumflexa femoris medialis is distinguishable at the stage of 24.8 mm. (Carnegie Embryo no. 840).

Resumen por el autor, John A. Kittelson.

Los efectos de la inanición y realimentación sobre el crecimiento del riñón de la rata albina.

El autor ha llevado a cabo un cuidadoso estudio volumétrico de la corteza y médula del riñón, así como una numeración completa de los corpúsculos renales (corpúsculos de Malpighi), basándose en cortes seriados del riñón de la rata albina hambrienta a consecuencia de una alimentación insuficiente administrada desde el nacimiento hasta las tres y seis semanas de edad, y en los del riñón de ratas en las cuales se ha mantenido constante el peso del animal desde el nacimiento hasta las tres semanas de edad. También ha estudiado el riñón de una rata realimentada hasta pesar 25.6 gramos, después de sometida a una alimentación insuficiente desde el nacimiento hasta las tres semanas, y el de otra rata realimentada hasta pesar 74 gramos y sometida previamente a alimentación insuficiente desde el nacimiento hasta las seis semanas, así como los riñones de ratas normales escogidas como término de comparación. Durante la alimentación insuficiente puede cesar la formación de nuevos corpúsculos en la corteza. Los esbozos de los corpúsculos que aparecen al comienzo de la alimentación defectuosa continúan su desarrollo, pero no aparecen nuevos esbozos. Los corpúsculos renales aumentan de tamaño durante el periodo de hambre y presentan una hipertrofia suficiente para compensar su escasez. Cuando el periodo de hambre es largo ocurre sin embargo que, con un aumento algo mayor de peso total y de peso del riñón, el impulso para formar nuevos corpúsculos vence a la inhibición producida por el hambre. De este modo el riñón hipertrofiado tiende a producir el número de corpúsculos normal para su peso. Los datos recogidos parecen demostrar que, manteniendo el mismo peso en el animal, la mayor parte del crecimiento del riñón tiene lugar en la médula. Esto está de acuerdo con los resultados obtenidos en las ratas normales. Parece pues que la inanición severa no es suficiente para inhibir el impulso de crecimiento de la médula.

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EFFECTS OF INANITION AND REFEEDING UPON THE GROWTH OF THE KIDNEY OF THE ALBINO RAT

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INTRODUCTION

The normal postnatal development of the rat's kidney, including renal corpuscles and volumetric growth of cortex and medulla, was described in a previous paper (Kittelson, '17). No detailed data on the kidney after conditions of inanition and refeeding seem to be available. Jackson ('15) found a slight increase in the weight of the kidneys in young rats held at maintenance (constant body weight) by underfeeding from three to ten weeks of age. Stewart ('16) found that the kidneys are of practically normal percentage weight in rats after maintenance from three to twelve weeks of age and throughout the period of refeeding. In underfeeding begun at earlier periods, however, he (Stewart, '18, '19) found a definite increase in the kidney weight. The effects of inanition and refeeding on the volumes of cortex and medulla and on the total number and volume of the renal corpuscles in young rats are the special problems for which data have been collected in the present investigation.

The work was done in the Anatomical Laboratory of the University of Nebraska. The problem was suggested by Prof. C. M. Jackson, University of Minnesota, and carried out under his supervision. I thank Doctor Jackson for his valuable aid and criticism. The material was given to me by Dr. C. A. Stewart, University of Minnesota, who fed, cared for, and autopsied the rats in connection with his inanition studies. I wish to express my thanks to Doctor Stewart for his generosity. I am also very grateful to Dr. C. W. M. Poynter, University of Nebraska, for his interest in the problem and for valuable suggestions.

MATERIAL AND METHODS

The material used included the kidneys of eight albino rats (*Mus norvegicus albinus*) from the rat colony in the Institute of Anatomy at the University of Minnesota. In addition to these test rats, six normal rats used in my previous study (V 2.1; V 2.2; V 1.3; V 13.1; V 1.7; V 1.8) were employed as controls. The kidneys of another new-born control rat (K 2.1) were studied and the number of renal corpuscles at birth more definitely determined. Data from Donaldson ('15) on kidney weights were also used for comparison. The general data are given in table 1. Of the test rats, two belonging to the same litter were stunted by underfeeding from birth to three weeks, a male (St 101.3) and a female (St 101.5). Two rats belonging to another litter were stunted by underfeeding from birth to six weeks, a male (St 100.1) and a female (St 100.2). Two female rats (St 214.2 and St 239.10) were held at maintenance (constant body weight) from birth to approximately three weeks (eighteen and twenty days, respectively). One female rat (St 106.1) was stunted by underfeeding from birth to three weeks (body weight 10.9 grams) and then refed to 25.6 grams (at five weeks of age). A male rat (St 91.8) was then stunted by underfeeding from birth to six weeks (body weight 13.5 grams) and then refed to 74 grams. This rat was killed at the age of thirteen weeks. During the underfeeding, the young nursing rats were at first removed from the mother for various periods up to the age of three weeks. Those in which the stunting continued to six weeks were fed

(after the weaning period) limited amounts of whole-wheat bread soaked in whole milk.

The identification numbers of the rats were used in the following way: the letters 'K' (Kittelson), 'St' (Stewart), and 'V' (Vaughn) indicate the series, the number preceding the decimal point designates the litter, while the number following the decimal point designates the individual rat.

The rats were killed with chloroform, weighed, and their nose-anus lengths measured. The two kidneys were then weighed together, and the weight of each kidney may be assumed to be one-half of the combined kidney weight. Individual kidney weights were not recorded.

One kidney (no record made of whether right or left) in each case was fixed in Zenker's fluid for eighteen to twenty-four hours, depending on the size. It was then imbedded in paraffin and cut in serial cross-sections $10\ \mu$ in thickness. The sections were then mounted in complete series and stained with haematoxylin and eosin.

The total volume of cortex and medulla was obtained by using the paper method explained in detail in a former paper (Kittelson, '17). The sections were enlarged by means of a Bausch & Lomb projection apparatus and the outlines of cortex and medulla were drawn on 'Byron Weston Ledger, Substance no. 32' (sheets 18 x 23 inches). The paper outlines were then cut out, weighed, and the data computed as explained in my previous paper. The paper used was slightly different from that formerly used. In order to reduce weight in grams to square area in centimeters, the weight was multiplied by 80.32, this representing the average area in square centimeters of one gram of the paper.

In table 1, the volumes of the kidneys used appear much smaller than might be expected from the corresponding weights. This difference is due to three factors: 1) the volume of the capsule and of the renal sinus (pelvis), both of which were excluded; 2) shrinkage of material in the process of preparation; 3) the specific gravity of the kidney, making the volume of the kidney in cubic centimeters somewhat less than the corresponding weight in grams.

In counting the number of malpighian corpuscles, the method used by Miller and Carlton ('95) was modified as in my former paper (Kittelson '17). In finding the average diameter of the malpighian corpuscles in the two zones, the paper method as used by Jackson ('17) was again followed.

Ferry ('13) showed that in rats refed after stunting the rate of growth is a function of size rather than of age. So far as possible, therefore, the test rats were compared with rats of about equal body weight. The limited number of observations make it impossible to draw any final conclusions, but the results are interesting and suggestive.

DATA AND DISCUSSION

1. Weights of the kidneys used

The weights of the kidneys in the normal (control) rats (table 1) correspond fairly well to those in rats of similar body length or weight in the tables of Donaldson ('15). Of the test rats, those stunted to three weeks (especially St 101.3) have kidney weights somewhat below the normal for corresponding body weight or length. Those stunted to six weeks have kidney weights below those for corresponding body length, but more nearly in agreement with the corresponding body weight. The two rats held at maintenance (constant body weight) for three weeks have kidney weights much above those for corresponding body weights (as found by Stewart, '19), but more nearly in agreement with those for body length. The two rats refed after stunting have kidneys slightly above the normal for corresponding body weight. The rats stunted to three and six weeks therefore appear exceptional, in that they fail to show the increase in weight of the kidneys as found by Stewart ('18). This must be kept in mind in interpreting the results.

2. Effects on cortex and medulla

The data showing the absolute growth in volume of medulla and cortex of the kidney are given in table 1. Data in terms of relative growth, which may be more easily comprehended, are also given in table 2.

The ratio between the volumes of medulla and cortex of the two rats stunted by underfeeding from birth to three weeks (St 101.3 and St 101.5) is 1:1.79, while the rats stunted from birth to six weeks (St 100.1 and St 100.2) show a ratio of medulla to cortex of 1:1.63. The rats held at maintenance from birth to three weeks (St 214.2 and St 239.10) show ratios of medulla to cortex of 1:1.44 and 1:1.47, while in normal rats of about equal body weight the ratio of medulla to cortex is 1:2.75 or 1:3.05. In normal rats of body weight about equal to those stunted from birth to three weeks the ratio between medulla and cortex is 1:2.91 or 1:2.02. The stunted rats of both periods therefore show a relative volume of cortex apparently below normal and this is more marked at the end of the longer inanition period and still more marked after the period of maintenance. A comparison of the absolute data (table 1) shows this to be due to an increase in the medulla rather than a decrease in the cortex.

The rat refed to 25 grams (St 106.1), after stunting from birth to three weeks, shows a ratio between medulla and cortex of 1:1.81. A normal rat of about the same body weight (V 13.1) has a ratio between medulla and cortex of 1:1.50. On refeeding to 74 grams (St 91.8), after stunting from birth to six weeks, the ratio between medulla and cortex becomes 1:1.95. This is very near the ratio between medulla and cortex in the normal twelve weeks' rat (V 1.8), which is 1:2.00. The cortex of the kidney has therefore increased at a more rapid rate than the medulla, on refeeding after inanition, so as to restore the normal ratio.

The volumetric relations between medulla and cortex are similarly evident from the percentages which each forms of their combined volume (table 2). In rats stunted from birth to three weeks, the medulla forms 36 per cent and the cortex 64 per cent, and in those stunted to six weeks the medulla forms 38 per cent and the cortex 62 per cent. In normal rats of similar body weight (V 2.2; V 1.3), the medulla forms 26 to 33 per cent and the cortex forms 67 to 74 per cent of the volume of the kidney. In rats held at maintenance for three weeks the medulla forms 41 or 42 per cent, while the cortex forms only 58 or 59 per

TABLE 1

RAT NUMBER	SEX	AGE	NOSE-ANTUS LENGTH	GROSS BODY WEIGHT	WEIGHT OF BOTH KIDNEYS	TOTAL VOL- UME OF ONE KIDNEY, COR- TEX, AND MEDULLA	VOLUME OF MEDULLA IN ONE KIDNEY	VOLUME OF CORTEX IN ONE KIDNEY	TOTAL NUM- BER OF RENAL COR- PUSCLES IN ONE KIDNEY	NUMBER OF RENAL COR- PUSCLES PER CU. MM. OF CORTEX
1. Normal rats (controls)										
K 2.1	M	Newborn	52	5.4	0.058	cu. mm. 13.7614	cu. mm. 3.6628	cu. mm. 10.0986	{ 15,940 ¹ 12,124 ²	{ 1,578 ¹ 1,201 ²
V 2.1	F	Newborn	51	5.2	0.055	13.1709	3.2504	9.9205	{ 15,533 ¹ 10,465 ²	{ 1,586 ¹ 1,057 ²
V 2.2	M	1 week	67	10.3	0.156	25.6952	6.5662	19.1290	19,682	1,028
V 1.8	M	2 weeks	69	11.8	0.169	44.5020	14.7160	29.7860	24,061	802
V 13.1	F	3 weeks	94	22.6	0.290	76.3424	30.5852	45.7572	25,930	566
V 1.7	M	7 weeks	122	44.6	0.498	131.7852	41.3524	90.4328	28,583	316
V 1.8	F	12 weeks	166	122.2	1.207	325.6988	106.6100	219.0888	28,863	131
2. Rats stunted from birth to three weeks										
St 101.3	M	3 weeks	66	11.5	0.1240	29.5572	10.6020	18.9552	14,661	773
St 101.5	F	3 weeks	67	11.0	0.1406	30.0716	10.7948	19.2768	14,428	748
3. Rats stunted from birth to six weeks										
St 100.1	M	6 weeks	80	13.4	0.1862	43.5330	16.5460	26.9870	26,071	966
St 100.2	F	6 weeks	78	13.6	0.2046	44.5610	16.9310	27.6300	26,165	946
4. Rats held at maintenance from birth to three weeks										
St 214.2	F	18 days	56	5.1	0.0900	20.7536	8.5056	12.2480	15,325	1,252
St 239.10	F	20 days	56	5.0	0.0750	17.6255	7.0502	10.5753	14,916	1,420
5. Rat stunted from birth to three weeks and refed										
St 106.1	F	5 weeks	95	25.6	0.3611	99.0500	35.1800	63.8700	31,447	492
6. Rat stunted from birth to six weeks and refed										
St 91.8	M	13 weeks	133	74.0	0.7794	170.780	57.7300	113.0500	32,826	290

¹ Including renal corpuscles still in stages of formation.² Including only fully formed corpuscles.

TABLE 2
Volumetric ratio of cortex and medulla in the kidney of normal and inanition rats.
Data derived from table 1

RAT NUMBER	AGE	RATIO OF MEDULLA TO CORTX	PERCENTAGE OF KIDNEY VOLUME FORMED BY		INDEX OF GROSS BODY WEIGHT (GRAMS) DIVIDED INTO VOLUME (CU. MM.) OF	
			Cortex	Medulla	Cortex	Medulla
1. Normal rats (controls)						
K 2.1	Newborn	1:2.75	73	27	1.87	0.64
V 2.1	Newborn	1:3.05	75	25	1.91	0.63
V 2.2	1 week	1:2.91	74	26	1.86	0.64
V 1.3	2 weeks	1:2.02	67	33	2.52	1.25
V 13.1	3 weeks	1:1.50	60	40	2.01	1.35
V 1.7	7 weeks	1:2.10	69	31	2.03	0.93
V 1.8	12 weeks	1:2.00	67	33	1.79	0.83
2. Rats stunted from birth to three weeks						
St 101.3	3	1:1.79	64	36	1.65	0.92
St 101.5	3	1:1.79	64	36	1.75	0.98
3. Rats stunted from birth to six weeks						
St 100.1	6	1:1.63	62	38	2.01	1.23
St 100.2	6	1:1.63	62	38	2.03	1.24
4. Rats held at maintenance from birth to three weeks						
St 214.2	18 days	1:1.44	59	41	2.40	1.66
St 239.10	20 days	1:1.47	58	42	2.11	1.41
5. Rat stunted from birth to three weeks and refed to 25.6 grams						
St 106.1	5 weeks	1:1.81	64	36	2.49	1.37
6. Rat stunted from birth to six weeks and refed to 74 grams						
St 91.8	13 weeks	1:1.95	66	34	1.53	0.78

cent. In new-born control rats of about equal body weight the medulla forms 25 to 27 per cent and the cortex 73 to 75 per cent. Kidneys of stunted rats therefore show a somewhat greater percentage of medulla as compared with kidneys from normal rats of corresponding body weight. This condition is most marked after maintenance (body weight held constant). In the refed rats the percentages are within the normal limits.

The relative growth of medulla and cortex may also be studied from a different point of view by comparing the volume of each with the corresponding total body weight. An arbitrary index of their relative growth is thus obtained, as shown in the last two columns of table 2. Some differences between the test animals and the normal controls are evident, but the data are too scanty to justify any definite conclusions, on account of the individual variability.

3. *Effects on the renal (malpighian) corpuscles*

a. *Total number of renal corpuscles after inanition and refeeding.* As shown in table 1, the total number of renal corpuscles at the end of stunting from birth to three weeks is 14,661 for rat St 101.3 and 14,428 for rat St 101.5. These numbers are intermediate between the number of fully formed corpuscles in the normal new-born rat (V 2.1), which is 10,465 (Kittelson '17) and the number of fully formed corpuscles in the normal rat of corresponding body weight (with somewhat larger kidney) at one week (V 2.2), which was found to be 19,682. If, however, the number of renal corpuscles still in stages of formation in V 2.1 (new-born) is added to the number of fully formed corpuscles, the resulting total number of corpuscles (15,533) is seen to be but slightly in excess of that found after underfeeding from birth to three weeks. In these cases, although the kidney failed to increase in weight, the maturation of renal corpuscles continued, although no new anlagen were formed.

In rats stunted by underfeeding from birth to six weeks (St 100.1, St 100.2), the number of corpuscles is 26,071 and 26,165, respectively. In these cases, the body weight and especially the kidney weight have increased, and the number of corpuscles approaches the full quota usually found in the normal rat kidney (28,000). No corpuscles in stages of formation were seen in the kidneys after either period of underfeeding.

In the rats held at maintenance from birth to three weeks (St 214.2 and St 239.10) the number of corpuscles are 15,325 and 14,916, respectively. The body weight has been stationary in

this case while the kidney weight has increased greatly. The number of corpuscles is practically the same with that found after stunting from birth to three weeks. From the above data it would seem that during underfeeding of greater or less severity the formation of new renal corpuscles may cease for a time, while those already partly formed become fully developed. If the period of underfeeding is lengthened, however, and the body weight be allowed to increase somewhat more, the kidneys increase in size and the formation of renal corpuscles may continue until the final number reached is practically normal, in spite of the continued underfeeding.

In the rat refed to 25.6 grams (St 106.1) after stunting from birth to three weeks, the number of renal corpuscles is 31,447. In the rat refed to 74 grams (St 91.8), after stunting from birth to six weeks, the number is 32,862. Both these numbers are in excess of the number found in the normal adult (28,000, according to Kittelson, '17). The differences are probably too great to be considered as due to individual variations or to errors in counting, although the data are too scanty to be certain. It is possible that the stimulus of underfeeding and refeeding leads to an overproduction of the renal corpuscles.

Noé ('00) noted considerable 'compensatory reparation' in body weight upon refeeding after inanition in rabbits, but in rats he found it to be less evident. He concluded that the compensation depends on the rate of restoration—when the recovery is more rapid, the compensation is less marked. Morgan ('06) points out that the greater power of assimilation of a regenerated part makes it possible for this part to draw the necessary nourishment from the blood, although the amount of nutriment in the blood is below that which is necessary to maintain a status quo in the differentiated tissues. "These slowly decrease in size and in the number of their cells, while the new part is increasing in size and in the number of its cells."

b. Number of renal corpuscles per cubic millimeter of cortex. The data are shown in table 1. The number of renal corpuscles per cubic millimeter of cortex in St 101.3 is 773 and in St 101.5 is 748. These two rats, which were stunted from birth to three

weeks, have an average total number of corpuscles of 14,580, which would normally occur somewhere between birth and one week of age. The number of renal corpuscles per cubic millimeter of cortex, however, would normally occur between two and three weeks of age (V 1.3 and V 13.1). This rapid extension or spreading out of cortical elements is due in part to the growth of the renal corpuscles themselves, but mostly to the rapid growth of the cortical tubules. The rats stunted by underfeeding from birth to six weeks (St 100.1; St 100.2) have 966 and 946 renal corpuscles per cubic millimeter of cortex, respectively. These are larger numbers than are found in the rats underfed for the shorter period. However, the rats stunted from birth to six weeks have almost twice as many corpuscles (total number) as the rats stunted from birth to three weeks. This would largely account for the greater number of corpuscles per cubic millimeter, which are in these rats more closely crowded together than in the normal rats at one week of age (V 1.3).

The rats held at maintenance from birth to three weeks (St 214.2 and St 239.10) have a total of 15,325 and 14,916 corpuscles, respectively, and 1252 and 1420 corpuscles per cubic millimeter of cortex. This condition would normally occur during the first week of life. It seems to show that during early maintenance by underfeeding the cortex nearly ceases to grow except for maturation of the anlagen of corpuscles present at birth. This is clearly indicated by the data for total volume of the cortex (table 1).

Upon refeeding to 25 grams, the number of corpuscles per cubic millimeter of cortex falls to 492. This corresponds very nearly with the normal number found in rats of similar body weight (V 13.1). In the rat refed to 74 grams after underfeeding from birth to six weeks, there are 290 corpuscles per cubic millimeter of cortex, which is somewhat higher than the number (131) seen in rat V 1.8, with a greater body weight, and slightly below that (316) seen in rat V 1.7, with a smaller body weight. This rapid decrease in the number of renal corpuscles per cubic millimeter of cortex during refeeding therefore corresponds to that found during the normal process of growth.

c. Diameter of the renal corpuscles. The diameters of the renal corpuscles are shown in table 3. After the stunting period from birth to three weeks, the diameters are very similar to those in the controls (V 2.2, V 1.3). The differences are small and of doubtful significance.

After underfeeding from birth to six weeks, there is in general an increase in the diameters of the renal corpuscles, especially in rat St 100.2, in which the average diameter exceeds that of the normal at three weeks (V 13.1) with much greater body weight and kidney weight.

After maintenance at constant body weight from birth to three weeks (St 214.2 and St 239.10) there is in general a decrease in diameters when compared with the controls of same body weight (K 2.1 and V 2.1).

After refeeding to 25 grams following stunting from birth to three weeks (St 106.1), the average diameter greatly exceeds this diameter in the normal rat with slightly lower body weight (V 13.1) and is practically equal to that in rat V 1.7, with much higher body weight and kidney weight.

After refeeding to 74 grams following underfeeding from birth to six weeks (St 91.8), the diameters of the renal corpuscles have increased so as to approach those of V 1.8, and are probably approximately normal for corresponding body or kidney weight.

In column g of table 3, the ratio between the number of corpuscles in equal areas of the outer and inner zones of the cortex are shown. They do not differ materially in the test rats and corresponding controls.

From the above data it would seem that underfeeding of young rats does not prevent the growth of renal corpuscles in size, which tends rather to exceed that in the normal kidney of corresponding weight. The shortage in numbers of the renal corpuscles in certain stages of underfeeding may be compensated in this way by increase in volume of the corpuscles. Also on refeeding after underfeeding from birth to three weeks, there is apparently some overgrowth or hypertrophy on the part of the renal corpuscles. That there is a relation between the total number of renal corpuscles and the average diameter of the renal cor-

TABLE 3
Comparative data on the size of the renal corpuscles in the kidney of normal and inanition rats

RAT NUMBER	AGE	DIAMETER OF RENAL CORPUSCLES FROM THE OUTER ZONE				DIAMETER OF RENAL CORPUSCLES FROM THE INNER ZONE				(g) RATIO OF NUMBER OF CORPUSCLES IN EQUAL AREAS OF OUTER AND INNER ZONE	(h) AVERAGE DIAMETER OF CORPUSCLES (ZONES CONSIDERED EQUAL IN VOLUME)	(i) AVERAGE DIAMETER OF CORPUSCLES CORRECTED FOR DIFFERENCE IN VOLUME OF OUTER AND INNER ZONES (ESTIMATED)	(j) TOTAL VOLUME OF CORPUSCLES IN ONE KIDNEY	RATIO OF TOTAL VOLUME OF CORPUSCLES TO	
		(a) Maximum	(b) Minimum	(c) Average	(d) Maximum	(e) Minimum	(f) Average	Kidney	Cortex						
1. Normal rats (controls)															
K 2.1	Newborn	80	40	60	98	56	72	57:43	63	62	1.50241	1:9	1:6.7		
V 2.1	Newborn	78	40	59	104	56	73	57.5:42.5	64	62	1.29475	1:10	1:7.6		
V 2.2	1 week	70	40	49	105	58	65	56.5:43.5	54	52	1.46708	1:11	1:13		
V 1.3	2 weeks	70	40	51	89	51	58	56:44	54	53	1.85960	1:23	1:16		
V 13.1	3 weeks	89	51	56	93	68	76	55.5:44.5	65	61	3.36586	1:22	1:13		
V 1.7	7 weeks	92	72	76	103	74	87	53:47	81	79	6.84566	1:19	1:13		
V 1.8	12 weeks	123	91	94	125	93	98	51:49	96	95	12.84648	1:12	1:17		
2. Rats stunted from birth to three weeks															
St 101.3	3 weeks	63	39	54	72	55	61	56.5:43.5	57	56	1.33884	1:22	1:14		
St 101.5	3 weeks	70	37	55	75	57	65	56:44	59	57	1.38942	1:21	1:13		

3. Rats stunted from birth to six weeks

St 100.1	6 weeks	75	42	53	81	54	62	54:46	60	59	2.78430	1:19	1:12
St 100.2	6 weeks	78	46	67	81	58	73	54:46	70	69	4.46964	1:10	1:6

4. Rats held at maintenance from birth to three weeks

St 214.2	18 days	74	40	54	75	54	62	56:44	58	56	1.48957	1:13	1:8
St 239.10	20 days	72	38	52	75	50	60	56:44	57	55	1.29049	1:13	1:8

5. Rats stunted from birth to three weeks and refed to 25.6 grams

St 106.1	5 weeks	85	67	81	86	70	83	54:46	81	81	8.69003	1:11	1:7
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6. Rats stunted from birth to six weeks and refed to 74 grams

St 91.8	13 weeks	104	76	85	118	79	97	50:50	91	89	12.03349	1:14	1:9
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puscles is indicated by the fact that while during normal development the number of corpuscles is increasing from birth to two weeks the average diameter of the corpuscles does not increase (Kittelson, '17).

d. Total volume of renal corpuscles and its ratio to that of the cortex and to the total kidney volume. Table 3 shows the total volume of the renal corpuscles and their ratio to the volume of the cortex and to that of the entire kidney. Those stunted by underfeeding from birth to three weeks and six weeks, and by maintenance to three weeks, correspond in general to the normal ratios, excepting rat St 100.2. In this rat, on account of the larger average diameter, the total corpuscular volume appears nearly twice the normal relative size. This hypertrophy of the corpuscles may be an effect of the experiment, although it does not appear in rat St 100.1, which was similarly treated.

The two rats refed after stunting both also show abnormally large relative volumes of the corpuscles, in proportion to kidney or cortical volume. This increase may be due in part to increase in the number of corpuscles, but is due chiefly to increase in average diameter (or volume) of the renal corpuscles.

DISCUSSION AND CONCLUSIONS

The variability of organs as to loss of weight during inanition has been explained in several ways. Manassein ('69) thought that the organs which are most active lose least during inanition. Paschutin ('81) thought that the organs lose in weight in proportion to their storage of available food. If the change in weight were due to the variation in food supply from the blood, then the renal corpuscles ought to maintain themselves much better and grow much faster than the tubules in young animals stunted by underfeeding. Huber ('06) proved conclusively by corrosion preparations (rat, dog, cat, guinea-pig, rabbit) that practically all the blood which nourishes the tubules of both cortex and medulla passes first through the renal corpuscles. The results in the longer underfeeding and refeeding experiments, in which the volume of the corpuscles is disproportionately large, may be due in part to this factor.

The present data indicate that during underfeeding the formation of new corpuscles in the cortex may cease (rats St 101.3, St 101.5, St 214.2, St 239.10). This is in general agreement with the well-known fact that inanition tends to prevent mitosis. For example, Jackson ('17) found that mitosis in the hypophysis ceases in rats held at maintenance by underfeeding from three to ten weeks of age, and reappears again on refeeding for one-half week or more. In these cases the anlagen of corpuscles present at the beginning of the underfeeding continue their process of development, but no new anlagen appear. The renal corpuscles grow in size during the underfeeding period and show a hypertrophy sufficient to overcome their lack in number (as shown by total volume of corpuscles). Sometime during the longer underfeeding period, however, with a somewhat greater increase in body weight and kidney weight, the impulse to form new anlagen (corpuscles) overcomes the inhibition caused by the underfeeding. Thus the hypertrophied kidney during underfeeding tends to develop the number of corpuscles normal for its weight.

Stewart ('19) has found that in new-born rats held at maintenance by underfeeding for two or three weeks the growth impulse in the kidney is very marked, so that it may even double its weight. The present data seem to show that only a small part of this growth takes place in the cortex and that it occurs mostly in the medulla. This is in accord with what was found from birth to three weeks in normal rats (Kittelson, '17). It would seem that the severe inanition of maintenance is not sufficient to inhibit the growth impulse of the medulla. Refeeding after stunting results not only in a hypertrophy of the renal corpuscles, but also in an increase in number, which may even exceed the normal. The data on this point are too few to be conclusive, but the indication is interesting.

SUMMARY

A careful volumetric study of the cortex and the medulla, together with complete enumeration of the renal (malpighian) corpuscles, was made upon serial sections of the kidney of the albino rat after stunting by underfeeding from birth to three weeks, from birth to six weeks, and after maintenance (constant body weight) from birth to three weeks. A rat which had been refed to 25.6 grams after stunting from birth to three weeks and a rat refed to 74 grams after stunting from birth to six weeks were also studied, together with normal controls. The principal results may be summarized as follows:

1. During underfeeding, especially when severe (maintenance), the loss in rate of growth in the medulla is less than in the cortex, which becomes relatively smaller in volume. The normal proportion is restored upon refeeding.

2. During the shorter underfeeding periods, formation of new renal corpuscles ceases, although the anlagen incompletely formed become fully developed. The deficiency in number of corpuscles is apparently overcompensated by a corresponding increase in the size of the corpuscles.

3. During the longer underfeeding period, with somewhat greater body and kidney weight, the formation of new corpuscles continues until practically the normal number is reached. Growth in size of the corpuscles also continues.

4. Refeeding after underfeeding apparently results in hypertrophy of the renal corpuscles, and an increase in their number even beyond normal.

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Resumen por el autor, A. R. Cooper.
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Sobre un caso de unión de la vena cava inferior con la vena
azigos del perro.

El autor describe una anomalía del sistema venoso del perro, en la cual la vena cava inferior en vez de seguir su curso normal a través del diafragma, pasa por detrás de este para unirse con la vena azigos, que a consecuencia de esto exhibe considerable tamaño. Las venas inter-costales mas posteriores y las lumbares mas anteriores presentan las conexiones normales con la vena azigos. Esta variación, que es evidentemente el tercer caso mencionado en el perro, representa probablemente la persistencia de la vena supracardinal derecha del embrión en todo su recorrido.

Translation by José F. Nonidez
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A CASE OF THE INFERIOR VENA CAVA UNITING WITH THE AZYGOS VEIN IN THE DOG

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TWO FIGURES

A short time ago, during the regular dissection of the dog in the laboratory, an anomaly of the venous system was met with, in which the inferior vena cava, instead of pursuing its normal course behind the liver and through the diaphragm, passed behind the latter and united with the azygos vein, which was consequently greatly enlarged to accommodate the extra volume of blood.¹ This variation, apart from being of interest from a comparative standpoint, was considered to be of sufficient importance embryologically to warrant its being described, especially since only two cases have already been recorded.

Up to the present about thirty cases of this variant have been reported for man by Kaestner ('00), Neuberger ('13), and others, and it has been observed in the guinea-pig, cat, and deer among the lower animals, but, so far as I have been able to ascertain, only twice has it been recorded as having been found in the dog. Ponsot ('57) described a case in which the inferior vena cava, after receiving the lumbar and renal veins in the normal manner on its way up through the abdominal cavity, passed behind the right crus of the diaphragm, "accompanied by the great splanchnic nerve," and united with the azygos vein opposite the sixth thoracic vertebra. At the level of the fourth thoracic vertebra the latter turned forward (that is, downward in the natural position of the dog) across the right bronchus and emptied by a trunk common to it and the superior vena cava into the right

¹ For the sake of ease in comparison the terms of orientation used in human anatomy are used here.

auricle. In the thorax it received the intercostal veins from the two sides, excepting those accommodated by that part of the azygos below the sixth thoracic vertebra, which was normal in its course. Furthermore, at the level of its crossing the bronchus it received a quite voluminous vein resulting from the union of the first two or three right intercostal veins—the right superior intercostals. He made no mention, however, of the left superior intercostals, so they probably emptied as usual into the left costocervical vein. The hepatic veins, on the other hand, united to form a common trunk which pierced the diaphragm and poured into the auricle as does the inferior vena cava ordinarily. In the case described by Korösy ('10) the inferior vena cava was likewise found to pursue a normal course up to the level of the renal veins, then to form a number of zig-zag coils before piercing the diaphragm and joining the azygos vein. In the thorax the latter continued without any coiling to its point of union with the superior vena cava. As in Ponsot's case, the hepatic veins also united to form a common trunk which followed the usual course of the inferior caval vein to the heart.

Before describing the present anomaly, what has been described as the normal, or better, the average origin and distribution of the azygos vein will be given for the sake of clearness. Ellenberger and Baum ('91) state that the azygos vein arises in the abdominal cavity as two small venous trunks, a right and a left, which run upward on the ventral surfaces of the vertebral muscles and between the pillars of the diaphragm and receive the last three intercostal veins symmetrically. The left one, which corresponds to the hemiazygos in man, joins the right at the level of the ninth or tenth rib. The main vessel—the azygos—continues upward on the right side of the bodies of the thoracic vertebrae and empties into the superior vena cava at the level of the fourth rib. It receives the ninth to the fourth pairs of intercostal veins, inclusive, besides posterior bronchial and oesophageal veins. The first three pairs of intercostals—the superior intercostals—pass into the costocervical vein through a common stem. In a recent confirmatory dissection, however, I found that the azygos vein did not originate as two stems, but

that it was unpaired and took a straight course from its point of union with the superior vena cava, opposite the sixth rib, to its origin in the abdomen, where it anastomosed with the first and second lumbar which passed directly into the inferior vena cava. The fourth, fifth, and sixth intercostals formed a common stem on each side before joining the main vessel. Below the sixth pair ten more pairs were given off symmetrically, so that behind the thirteenth intercostal (subcostal) there were three other pairs. These I considered to be the superior lumbar. No median sacral vein was present in this specimen, but the inferior vena cava received four pairs of lumbar veins, the first pair being situated between the renals and the lumbo-abdominals. The latter were bilaterally symmetrically arranged and received the suprarenal and inferior phrenic veins, other small inferior phrenics emptying directly into the inferior vena cava just above the lumbo-abdominals. Thus there were present the seven pairs of lumbar veins described by Ellenberger and Baum, but three were tributaries of the azygos and only four of the inferior vena cava.

In the case of the anomaly I found that the inferior vena cava was normal up to the level of the renal veins, excepting that instead of the usual six or seven pairs of lumbar there were only four pairs, the last uniting with the median sacral by a common stem. The first two or three lumbar were consequently represented at least in part (*vide infra*) by tributaries of the lumbo-abdominal veins, as shown for the right side in figure 2B. Above the renals the inferior vena cava then inclined to the right as it became greatly enlarged, and passed into the thorax through the triangular foramen—normally closed by only two thin layers of thoracic and abdominal peritoneum—which is bounded behind by the body-wall, laterally by the costal portion of the diaphragm, and medially by the crus, and is met at its apex by the narrow posterior limb of the central tendon (fig. 1). In the thorax it joined the greatly enlarged azygos vein at about the level of the eleventh rib (fig. 2A). Before piercing the diaphragm, however, it received the right inferior phrenic, suprarenal and lumbo-abdominal veins, and

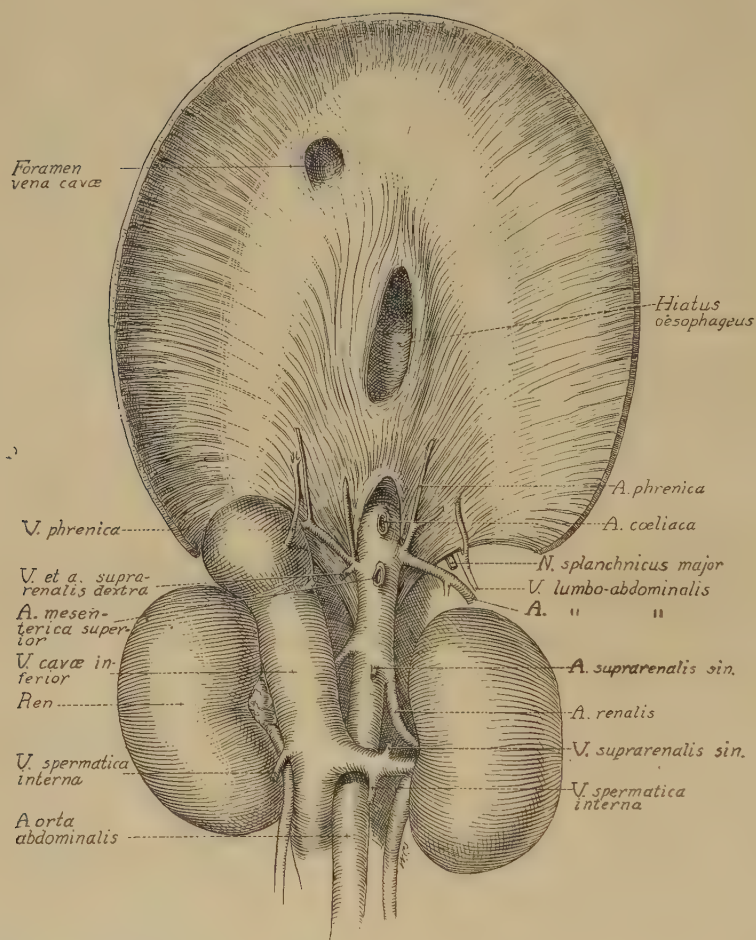


Fig. 1 View of the inferior vena cava and the principal branches of the abdominal aorta immediately below the diaphragm.

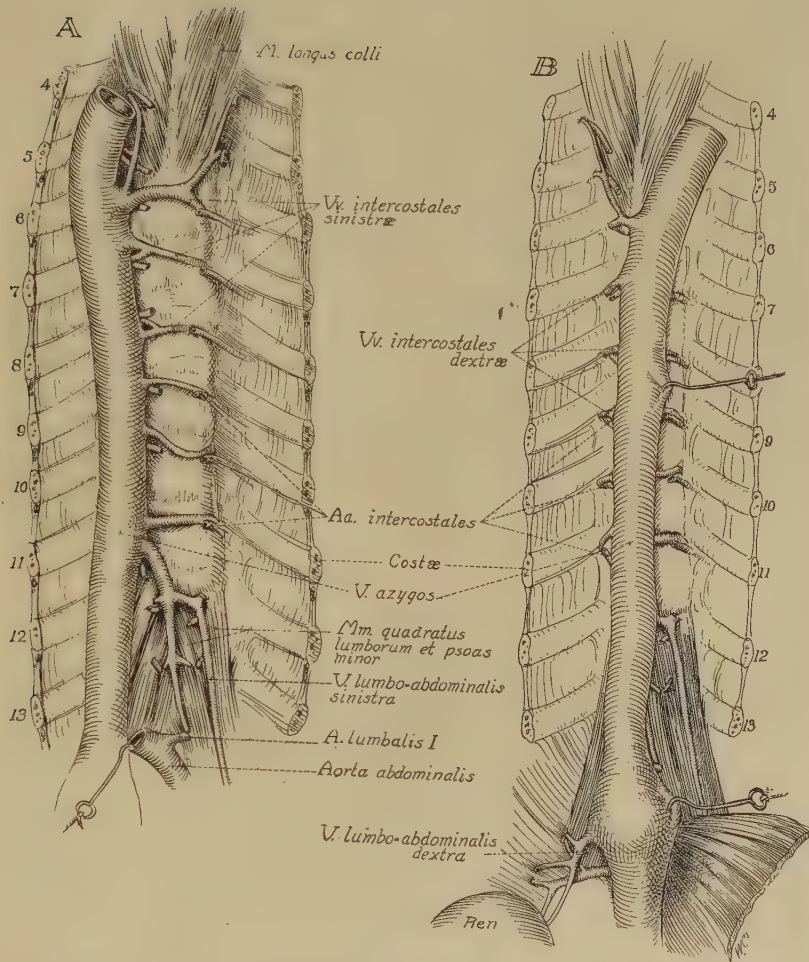


Fig. 2 A. View of the union of the inferior vena cava with the azygos vein in the thorax. B. Same with the main trunk displaced to the left per.

became greatly enlarged (fig. 1) to form a pronounced aneurysm. On opening this aneurysm, I found nothing which might point to its cause: the vessel was smooth inside and the wall was quite thin. The costal and crural margins of the foramen through which the vessel passed were so closely and firmly applied to it that it was somewhat grooved just above the enlargement. Hence the aneurysm may have been caused in later life by the partial damming up of the blood in the vessel by the comparatively unyielding margins of the opening and the concomitant unusual pressure on a possibly weaker wall in that region. Or, on the other hand, it may represent a local enlargement of the original supracardinal plexus, which was formed very early in the development of the whole vein (cf. *infra*). In figure 1 it is to be seen that the left lumbo-abdominal vein was unusual in that it did not unite with the inferior vena cava as did the right, but after being joined by the left inferior phrenic passed behind the left crus of the diaphragm and into the thorax. There, as shown in figure 2A, it emptied in conjunction with the left twelfth intercostal into a larger vessel which in turn joined the main trunk at the level of the posterior margin of the eleventh rib.

The latter vessel arose in the median line immediately above the common stem of the first pair of lumbar arteries and received both of the thirteenth and the right twelfth intercostals. Hence it may be considered to represent in part at least the fused stems of origin of the azygos described by Ellenberger and Baum. Its lowermost end will then correspond to the first pair of lumbar veins in the more normal relations. The main trunk had no tributaries between this vessel and the right lumbo-abdominal vein. Above the posterior margin of the eleventh rib, however, it was joined by the fourth to the eleventh intercostal veins of the two sides, inclusive, arranged in pretty much the usual manner. The seventh and eighth pairs had common stems, while the fourth, fifth, and sixth also united with each other to form a pair of larger vessels at the level of the sixth rib (figs. 2A,B). Finally, at about the level of the fourth rib, the main trunk united either with the superior vena cava or passed directly

into the right auricle; unfortunately, the heart had been removed before the anomaly was discovered. Hence the azygos vein in this case may be considered to be represented by that part of the main vessel between the heart and the posterior margin of the eleventh rib plus the more medial terminal portion arising parallel to the first lumbar arteries, and the inferior vena cava may be looked upon as having united with the azygos vein in the region of the eleventh costal interspace.

Owing to the fact that the liver had also been removed before I discovered the variant, I did not ascertain the disposition of the hepatic veins with certainty. However, as shown in figure 1, there was a foramen in the diaphragm in the usual position of that accommodating the inferior caval vein. There was also a distinct groove between the medial and the lateral lobes of the right lung, similar to that through which the vessel usually runs in the thorax. Thus the evidence is that, as in Ponsot's and Korösy's cases, the hepatic veins formed a common trunk that pursued the usual course of the inferior vena cava above the liver.

This anomaly is of special significance from an embryological viewpoint, since in all probability it represents the persistence of the right embryonic supracardinal vein throughout its entire extent. According to Huntington and McClure ('07), the postrenal division of the inferior vena cava and the lumbar and posterior part of the thoracic portion of the azygos vein are derived from the supracardinal veins and Professor McClure assures me that it is the right supracardinal which persists as the inferior caval vein below the diaphragm. The vein which, as shown in figure 2, is formed by the union of the left lumbo-abdominal and the left twelfth intercostal veins is consequently the remains of the thoracic division of the left embryonic supracardinal, the abdominal division being represented at least in part by that portion of the lumbo-abdominal in question below the diaphragm.

In conclusion, I wish to express my indebtedness to Professor McClure for assistance with the literature and for an expression of opinion on the embryological significance of this anomaly.

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PROCEEDINGS OF THE AMERICAN SOCIETY OF ZOÖLOGISTS

SEVENTEENTH ANNUAL MEETING

The American Society of Zoölogists held its Seventeenth Annual Meeting in conjunction with Section F of the American Association for the Advancement of Science and the Ecological Society of America, December 29, 30 and 31, in the Soldan High School building, St. Louis, Missouri. President C. M. Child presided throughout the meeting. The other officers for the year were: *Vice-President*, H. H. Wilder; *Secretary-Treasurer*, W. C. Allee; *Executive Committee*, L. J. Cole, R. P. Bigelow, H. V. Wilson, M. M. Metcalf, George Lefevre; *Member Council* A. A. A. S., C. P. Sigerfoos; *Local Representative*, Caswell Grave.

BUSINESS SESSIONS

The main business session extended from 9:50 to 11:00 o'clock, December 31. A preliminary business session was held on the afternoon of December 29, and resolutions were read and adopted at the Zoölogy dinner on the evening of the 31st. At these sessions the following business was transacted:

Election of Members

The Executive Committee recommended the following persons for election to membership in the Society:

1. ALLEN, GEORGE DELWIN, M.S. (Chicago) and Ph.D. (Minnesota), Instructor in Zoology, Department of Animal Biology, *University of Minnesota, Minneapolis, Minn.*
2. BELLAMY, ALBERT W., Ph.D. (Chicago), Instructor in Zoology, *University of Chicago, Chicago, Ill.*
3. BOECK, WILLIAM CHARLES, B.S., M.A., Ph.D., Research Fellow, Rockefeller Foundation at The Johns Hopkins School of Hygiene and Public Health. *310-312 West Monument St., Baltimore, Md.*

4. ESTERLY, CALVIN O., Ph.D., Professor of Zoology, *Occidental College, Los Angeles, Calif.*
5. HANSON, FRANK BLAIR, A.B., A.M., Ph.D. (Illinois), Assistant Professor of Zoology in Washington University, *Washington University, St. Louis, Mo.*
6. JOHNSON, CHARLES EUGENE, M.A., Ph.D., Assistant Professor of Zoology, *University of Kansas, 616 West 17th St., Lawrence, Kansas.*
7. JUST, ERNEST EVERETT, Ph.D. (Chicago), Professor of Zoology, *Howard University, Washington, D. C. 412 T St., Washington, D. C.*
8. KINDRED, JAMES ERNEST, A.B., A.M., Ph.D. (Illinois), Instructor in Biology, *Western Reserve Dental School, Cleveland, Ohio. 1353 E. 9th St., Cleveland, Ohio.*
9. LYNCH, RUTH STOCKING (Mrs.), A.B. (Goucher), Ph.D. (Johns Hopkins), Instructor, Dept. of Protozoology, *School of Hygiene and Public Health, The Johns Hopkins University. 3 A Seville Apartments, Lake Drive, Baltimore, Md.*
10. MAGATH, THOMAS BYRD, Ph.B. (Emory University, Georgia, 1913), M.S. (Millikin University, Ill., 1914), Ph.D. (University of Illinois, 1917), M.D. (University of Illinois, 1919), Parasitologist, *Mayo Clinic, Rochester, Minnesota.*
11. MAVOR, JAMES WATT, B.A. (Cantab.), Ph.D. (Harvard), Assistant Professor of Zoology, *Union College, Schenectady, N. Y.*
12. MINNICH, DWIGHT ELMER, A.B. (Miami, 1910), Ph.D. (Harvard, 1917), Instructor in Zoology, *Syracuse University, Syracuse, N. Y.*
13. MOORE, CARL R., Ph.D. (Chicago), Instructor in Zoology, *University of Chicago.*
14. NELSON, THURLOW CHASE, B.A. (Rutgers), Ph.D. (Wisconsin), Assistant Professor of Zoology, *Rutgers College, New Brunswick, N. J.*
15. NOWLIN, NADINE (Miss), A.B., A.M., Assistant Professor of Zoology, *University of Kansas, 1144 Louisiana St., Lawrence, Kansas.*
16. O'DONOGHUE, CHARLES H., D.Sc. (London), F. Z. S., Professor of Zoology, *University of Manitoba, Winnipeg, Canada.*
17. ROBERTSON, ALBERT DUNCAN, B.A. (Toronto), Professor of Biology, *Western University, London, Ont., Canada, Dept. of Biology, Western Univ., London, Ont., Canada.*
18. ROOT, FRANCIS METCALF, A.B., A.M. (Oberlin), Ph.D. (Johns Hopkins), Teaching Fellow in Medical Entomology, *School of Hygiene and Public Health, Johns Hopkins University. 310-312 West Monument St., Baltimore, Maryland.*
19. SMITH, ELIZABETH ANITA, A.B., M.A., Ph.D. (Wisconsin), Assistant Professor, *University of Wisconsin, Biology Bldg., Madison, Wisconsin.*
20. STONER, DAYTON, A.M., Ph.D., Associate in Zoology (a rank higher than instructor in this university), *State University of Iowa, 603 Summit Street, Iowa City, Iowa.*
21. WHITE, GERTRUDE MAREAN, B.A. (Milwaukee-Downer), M.A., Ph.D. (Wisconsin), Instructor in Biology, *Margaret Morrison Carnegie School, Carnegie Institute of Technology, Pittsburgh, Pa.*

22. YOSHIDA, SADAŌ, Japanese university degrees equivalent to our B.S., A.M., Ph.D., Professor of Parasitology and General Zoology in Osaka Medical College, Japan, since 1914. 1919-1920, Fellow in Zoology, *University of Illinois, Natural History Hall, Urbana, Illinois*. Home Address: *Osaka Medical College, Osaka, Japan*.

All were duly elected.

Report of Secretary-Treasurer

As Secretary, W. C. Allee reported that one member, William Erskine Kellicott, and one former member, George Lester Kite, had died during the year; that five members resigned from the Society, and two members were dropped from the roll for non-payment of dues.

The Secretary also thanked the members of the Society for their thoughtfulness in notifying him when unable to be present at the meetings after having listed papers.

For information of the Society it was reported that an examination of the membership roll showed that 154 members live east of a line drawn through western Pennsylvania, and 157 members live west of that line.

As Treasurer, W. C. Allee submitted the following report for the year 1919:

Receipts

Balance on hand at last report of preceding treasurer.....	\$737.79
Interest to January 1 on Savings Account No. 635 of Title Guarantee and Trust Co., Baltimore, Md.....	8.60
Total received from preceding treasurer.....	\$746.39
71 \$5.00 dues.....	\$355.00
207 7.00 dues.....	1449.00
20 11.50 dues.....	230.00
1 10.50 dues (Life Member).....	10.50
1 22.00 dues.....	22.00
1 .50 dues.....	.50
1 .50 Overpayment.....	.50
1 3.00 Overpayment.....	3.00
Total receipts from dues.....	\$2070.50
Interest on savings deposit at 3% July 1.....	28.33
Total cash received.....	\$2845.22

Expenditures

January to December, 1919, inclusive, to The Wistar Institute for subscriptions:

1 at \$20.00.....	\$20.00
15 at 11.00.....	165.00
59 at 4.50.....	265.50
169 at 6.50.....	1098.50
244 Subscriptions.....	\$1549.00

Expenses office of Secretary-Treasurer:

Stenography and typewriting.....	\$25.87
Printing and mailing cards for membership dues.....	15.48
Mailing announcements.....	4.40
Stamps.....	14.28
Telephone and telegrams.....	1.85
Printing announcements and envelopes.....	17.00
Refund of overpaid dues.....	3.50
Letter file and rubber stamp.....	1.00
Express records and typewriter to Woods Hole.....	6.24
Carfare during year.....	2.30

Total.....\$91.92

Total expenditure.....\$1640.92

Cash on hand, December 27, 1919

Savings deposit.....	\$1154.74
Checking deposit.....	49.56

Total.....\$1204.30

Total cash received during year.....\$2845.22

Total expenditures to date.....1640.92

Excess receipts over expenditures.....\$1204.30

Bills due, payable January 1, 1920

Wistar Institute Journals:

12 at \$4.50.....	\$54.00
38 at 6.50.....	247.00
6 at 11.00.....	66.00

Total.....\$367.00

Secretary's expenses to St. Louis Meeting.....41.98

Total.....\$408.98

Cash receivable

35 members' dues for total of 52 years.....	\$358.00
Interest on savings at 3% due January 1.....	14.27

Probable balance January 1

Balance, December 27, 1919.....	\$1204.30
Interest.....	14.27
Bills payable January 1.....	408.98
Probable balance January 1, 1920.....	\$809.59
Balance January 1, 1919.....	746.39
Increase for year.....	\$63.20

The Auditing Committee, consisting of Charles Zeleny and W. C. Curtis, examined and approved the accounts.

Advisory Board

At the request of Frank R. Lillie, Chairman of the Committee on Coöperation and Coördination of the Division of Biology and Agriculture of the National Research Council, the Executive Committee approved, and the Society passed the following resolution:

Resolved, That there be established a permanent committee to be called the Advisory Board of the American Society of Zoölogists, consisting of eight members appointed by the Executive Committee, two each for periods of one, two, three, and four years; and thereafter two each year for a four-year term. The Chairman of the Board shall be elected annually by the Board.

The duties of the Board shall be:

1. To represent the American Society of Zoölogists before the National Research Council.
2. To correlate the various research agencies of the country in zoölogy; including various government bodies, both national and State, museums, research establishments, and universities.
3. To promote international relations in zoölogy.
4. To take up other problems for the promotion of research in zoölogy, subject to the approval of the Executive Committee.

President Child announced the appointment by the Executive Committee of the following Advisory Board:

F. R. Lillie

J. T. Patterson

Wm. E. Castle

M. M. Metcalf

C. C. Nutting

V. E. Shelford

G. N. Calkins

Robert Chambers, Jr.

The Journal of Morphology

Owing to the request of Prof. J. S. Kingsley to be relieved of the editorial management of the *Journal of Morphology* at a date in 1920 not yet definitely fixed, The Wistar Institute, through M. J. Greenman, its director, approached the American Society of Zoölogists, proposing that the Society assume responsibility for the scientific policy and the election of the Editorial Board of the *Journal of Morphology*, subject to the approval of the Advisory Board of The Wistar Institute, and full financial responsibility of the *Journal* to be kept by The Wistar Institute.

Doctor Greenman further proposed that the Society appoint a small special Committee on Publication, which should meet with the Advisory Board of The Wistar Institute in Philadelphia at certain of its regular meetings held in April to discuss journal affairs in general and those of the *Journal of Morphology* in particular.

Whenever the Committee is called to attend a meeting in Philadelphia, all expenses of travel and entertainment incident thereto are to be paid by The Wistar Institute.

After discussion it was voted to approve the general proposition of assuming responsibility for the scientific policy and the appointment of the Editorial Board of the *Journal of Morphology*, and the Executive Committee was instructed to appoint a Committee of Publication whose duties would be:

1. To initiate a scientific policy concerning the *Journal of Morphology*.
2. To nominate an Editorial Board.
3. To consult with the Advisory Board of The Wistar Institute concerning both the proposed policy and the editorial nominations.

4. To refer the recommendations for final decision to the Executive Committee in 1920, and thereafter through the Executive Committee to the Society at its Annual Meeting.

New by-law

The following new by-law was adopted:

By-laws (Add) No. 4

The National Research Council allows the Society three representatives on the Division of Biology and Agriculture. Of these three representatives, one shall be elected each year to serve three years. The method of election shall be the same as that used in the election of the officers of the Society.

Proposed change in Constitution

Although final action could not be taken at this meeting, the following proposed amendment to the Constitution was read:

Article II (Add) Section 4.

Honorary Fellows, regardless of membership in the Society, may be elected upon unanimous recommendation of the Executive Committee, by a majority vote of the members present at any meeting of the Society. The number of Honorary Fellows shall be limited to ten, and not more than one shall be elected at any one meeting of the Society. Honorary Fellowship does not involve the payment of dues nor does it confer the right to vote.

After discussion, it was voted that any amendment to the Constitution shall not contemplate the elevation of members of the Society, and that Honorary Membership shall be limited to members of foreign societies.

Resolutions

The Resolution Committee, consisting of Caswell Grave, Bennett M. Allen, and Chauncey Juday, reported the following

resolutions, which were adopted by standing vote and ordered spread on the records:

WILLIAM ERSKINE KEL LICOTT

1878-1919

Mindful of the great loss sustained by the American Society of Zoölogists and zoölogical science in the death of William Erskine Kellicott, the members of the Society find comfort and satisfaction in recalling the mature and substantial character of his scientific contributions, the unusual abilities he displayed as a teacher of zoölogy, and above all the pleasing personality of their co-worker and friend.

The Society, therefore, desires to record this minute in recognition of his services to zoölogical science and to mankind.

GEORGE L. KITE

1882-1919

During the brief period of his labors, George L. Kite showed special aptitude and an adequate preparation for the investigation of the difficult problems which lie in the field where zoölogy, chemistry, and physics meet. His loss is only partially repaired by the inspiration which the methods he developed and the results he attained are affording to the workers who have taken up the problems he relinquished.

The American Society of Zoölogists places this minute on record, thereby expressing its regret at the early loss of this promising member.

Election of Officers

The Nominating Committee (see Art. 2, Sect. 6), composed of S. O. Mast, V. E. Shelford, and B. M. Allen, reported the following nominations:

President, Gilman A. Drew.

Vice-President, Caswell Grave.

Member of Executive Committee to serve five years, C. M. Child.

Member of Division of Biology and Agriculture, National Research Council, to serve three years, F. R. Lillie.

Nominations from the floor were called for, but none were suggested, and the officers as presented by the Nominating Committee were duly elected.

On nomination of the Executive Committee, C. C. Nutting was elected member of the Council of the American Association for the Advancement of Science in place of C. P. Sigerfoos, resigned.

Sessions for the presentation and discussion of papers

At the meeting of the Society for the presentation and discussion of papers, a total of forty-two papers were presented in full, and twenty-eight were read by title. Seventeen of the papers were followed by discussion.

The sessions were occupied as follows:

Monday, December 29. Morning: Embryology and Cytology. Afternoon: Cytology and Parasitology.

Tuesday, December 30. Morning: By arrangement with the Botanical Society of America, Genetic papers were called at this session. Afternoon: Joint session with the Ecological Society of America, at which the following program was presented:

STEPHEN E. WILLIAMS, Miami University. Observations on the habits of larval colonies of *Pectinatella*. (A. S. Z.)

V. E. SHELFORD, Illinois Natural History Survey. Hydrogen ion concentration in the different stages of pond succession. 15 min. (E. S. A.)

The discussion will cover the plants and animals present; H ions in different stages; the reactions of fishes to H ions in relation to succession; comparison of ponds with streams and bayous; seasonal differences.

W. C. ALLEE, Lake Forest College. Animal aggregations. (A. S. Z.)

A. D. HOWARD, U. S. Bureau of Fisheries. Distribution of life on a river bottom. 15 min. (E. S. A.)

In an investigation to determine the distribution of fresh-water mussels, a somewhat detailed study was made of the whole bottom in a portion of a river. The area studied was a three-mile section of one channel of the Mississippi River between Rock Island, Illinois, and Muscatine, Iowa. The river in this section is comparatively straight and of rather uniform character (gradient, depth, etc.) passing over soil of clay, sand, and sedimentary rock (mostly limestone).

The life on the bottom was found to have a rather definite distribution with reference to physiographic features of the river. In general this benthos was restricted to a zone 200 feet wide along each shore. Where islands occurred, a narrower zone was found along the shores of the islands. This zone apparently had no particular relation to depth of water, as the middle area of the stream, about 500 feet wide, was no deeper than the 200-foot strips along shore. The latter are by no means equally productive throughout. The more densely populated portions are unquestionably distributed in relation to definite positions of the channel and other features. The channel being defined as the main body of flowing water in the river following usually the more excavated portion of the stream bed. On account of the changeableness of the channel in sandy sections of the river, features which insured permanency of condition were found an important factor in the bottom life at any given place.

The productive areas were usually parts of the shore strips that were bathed by the current; that is, in general, where the channel approaches the shore. Character of soil was a determining feature as in other bodies of water, but this is often controlled by current, relation to channel, topography, and such features. The possibility of greater food content of the water at the more productive areas was considered but not investigated in this particular locality as there seemed to be no reason for expecting it to be an important variable here. Doubtless, there is some local effect from contributions of the banks and the plankton of small tributaries.

In the life zones variation from swift to comparatively slow water was observed accommodating species adapted to these varied habitats.

CHAUNCEY JUDAY, Wisconsin Natural History Survey. Behavior of the larvae of *Corethra punctipennis* Say. (A. S. Z.)

A. D. HOWARD, U. S. Bureau of Fisheries. Changes observed in river fauna above Keokuk Dam. 15 min. (E. S. A.)

Keokuk Lake five years after its formation by the dam across the Mississippi River was examined to determine some of the effects of the changed conditions. In the portions of the lake occupying the bed of the river it was possible to examine productive life areas and compare the conditions with those existing in the former river. Some lands flooded by the elevation of the water have since been reclaimed by dyking. These give the opportunity to study advantageously the extension of pioneer aquatic species in the brief interval of submergence. Animals in the productive life areas of the former river-bed are subjected to a considerable decrease in current, an increase in depth of water with a heavy precipitation of fine black mud. Collections very obviously show the suppression of characteristic river species and the increase of pond or lake dwelling forms. A conspicuous increase in aquatic plants as compared with the usual river flora was observed.

LESLIE B. AREY, Northwestern University, and W. J. CROZIER, University of Chicago. On the natural history of *Onchidium*. (A. S. Z.) (By title.)

ROYAL N. CHAPMAN, University of Minnesota. Ecological succession of insects in stored food products. 15 min. (E. S. A.) (By title.)

A. A. SCHAEFFER, University of Tennessee. On a new principle underlying movement in organisms. (A. S. Z.)

Wednesday, December 31. Morning: Business session followed by papers in General Physiology and Comparative Anatomy. Afternoon: The Invitation Program. This meeting was held in the main auditorium. Evening: Following the Zoölogy dinner, William Patten gave the address of the retiring Vice-President of Section F. Subject, "The Message of the Biologist." This will be published in full in *Science*.

C. C. Nutting presented and explained three reels of motion-picture films taken on his recent Antigua-Barbados collecting trip.

At 10:00 P.M., after seven consecutive sessions, the Society adjourned *sine die*.

C. M. CHILD, *President*.

W. C. ALLEE, *Secretary-Treasurer*.

LIST OF TITLES

The titles have been arranged by the Secretary of the Zoologists according to the rules of the Society, in the order of their arrival.

Papers marked with an asterisk were read by title.

EMBRYOLOGY

- *1. The individuality of the germ-nuclei during the cleavage of the egg of *Cryptobranchus alleghehiensis*. Bertram G. Smith, Michigan State Normal College.
- *2. A sex intergrade pig which resembles a free-martin. Will Scott, Indiana University.
- 3. Retention of dead fetuses in utero and its bearing on the problems of superfetation and superfecundation. Albert Kuntz, St. Louis University, School of Medicine.
- *4. An explanation of the early development of the peripheral nervous system in the vertebrate embryo. H. H. Lane, University of Oklahoma.
- 5. The thyroid and parathyroid glands of *Bufo* tadpoles deprived of the pituitary glands. Bennet M. Allen, University of Kansas.
- 6. The influence of thyroid extirpation upon the various organs of *Bufo* larvae. Bennet M. Allen, University of Kansas.
- 7. Stages in the development of the thymus, parathyroid and ultimobranchial bodies in turtles. Charles Eugene Johnson, Department of Zoology, University of Kansas (introduced by Bennet M. Allen).
- 8. The results of the extirpation of the thyroid and of the pituitary anlagen on the interrenal tissue in *Rana pipiens*. Alice L. Brown, Kansas State Agricultural college (introduced by B. M. Allen).

CYTOLOGY

- *9. The effect of hypotonic and hypertonic solutions on fibroblasts of the embryonic chick heart in vitro. M. J. Hogue, School of Hygiene and Public Health, Johns Hopkins University.
- *10. Coelenterates and the evolution of germ cells. George T. Hargitt, Syracuse University.
- 11. Cytological criteria for the determination of Amoebic cysts in man. S. I. Kornhauser, Denison University.
- 12. The spermatogenesis of *Anolis carolinensis*. Theophilus S. Painter, University of Texas.
- *13. The presence of a longitudinal split in chromosomes prior to their union in parasynapsis. W. R. B. Robertson, University of Kansas.
- 14. Chromosome studies in Tettigidae. II. Chromosomes of BB, CC, and the hybrid BC in the genus *Paratettix*. Mary T. Harman, Zoology Department, Kansas State Agricultural College.

PARASITOLOGY

- 15. Notes on the life-cycle of two species of *Acanthocephala* from fresh-water fishes. H. J. Van Cleave, University of Illinois.

16. On the life-history of the gape-worm (*Syngamus trachealis*). B. H. Ransom, U. S. Bureau of Animal Industry, Washington, D. C.
17. A new bladder fluke from the frog. John E. Buberlet, Oklahoma Agricultural Experiment Station, Stillwater, Okla..
18. Studies on the development of *Ascarida perspicillum*, parasitic in fowls. James E. Ackert, Kansas State Agricultural College.
- *19. New data bearing on the life-history of *Sarcocystis tenella*. John W. Scott, University of Wyoming.
20. Contributions to the life-history of *Gordius robustus* Leidy. H. G. May, Mississippi College.
21. *Leucochloridium problematicum* N. sp. (Lantern.) Thomas Byrd Magath, Mayo Clinic.
22. Two new genera of *Acanthocephala* from Venezuelan fishes. H. J. Van Cleave, University of Illinois.
- *23. Note on the behavior of embryos of the fringed tapeworm. John W. Scott, University of Wyoming.
24. Contributions to the life-history of *Paragordius varius* (Leidy). H. G. May, Mississippi College.

GENETICS

25. Selection for increased and decreased bristle number in the mutant strain 'reduced.' F. Payne, Indiana University.
26. The mutational series, full to ultra bar, in *Drosophila*. Charles Zeleny, University of Illinois.
27. Variation in the percentage of crossovers and selection in *Drosophila melanogaster*. J. A. Detlefsen and E. Roberts, College of Agriculture, University of Illinois.
28. Inheritance of color in the domestic turkey. W. R. B. Robertson, University of Kansas.
29. Heredity of orange eye color. F. Payne and Margaret Denny, Indiana University.
30. The tabulation of factorial values for eye facet number in the bar races of *Drosophila*. Charles Zeleny, University of Illinois.
31. Linkage of genetic factors in mice. J. A. Detlefsen and E. Roberts, College of Agriculture, University of Illinois.
32. Forty-two generations of selection for high and low facet number in the white bar-eyed race of *Drosophila*. Charles Zeleny, University of Illinois.
33. On the inheritance of congenital cataract in dairy cattle. J. A. Detlefsen and W. W. Yapp, College of Agriculture, University of Illinois.

ECOLOGY AND GENERAL PHYSIOLOGY

34. Observations on the habits of larval colonies of *Pectinatella*. Stephen R. Williams, Miami University.
35. Animal aggregations. W. C. Allee, Lake Forest College.
36. Behavior of the larvae of *Corethra punctipennis* Say. Chancey Juday, Wisconsin Natural History Survey.

- *37. Studies on chitons. W. J. Crozier, Hull Zoölogical Laboratory, the University of Chicago.
- *38. On the natural history of *Onchidium*. Leslie B. Arey and W. J. Crozier, Northwestern University, University of Chicago.
- *39. The olfactory sense of Orthoptera. N. E. McIndoo, Bureau of Entomology, Washington, D. C.
- 40. On a new principle underlying movement in organisms. A. A. Schaeffer, University of Tennessee.
- 41. The relation of the concentration of oxygen to the rate of respiratory metabolism in *Planaria*. E. J. Lund, Laboratory of General Physiology, University of Minnesota.
- *42. Experimental studies on the cerebral cortex and corpus striatum of the pigeon. F. T. Rogers, Marquette School of Medicine.
- *43. Photic orientation in the drone-fly, *Eristalis tenax*. S. O. Mast, The Johns Hopkins University.
- *44. Behavior of a tunicate larva. W. J. Crozier, the University of Chicago.
- *45. Vision in the seventeen-year locust, *Cicada septendecim*. S. O. Mast, The Johns Hopkins University.
- *46. Periodicity in photic responses in the euglenoid, *Septocinclis texta*, and its bearing on reversion in the sense of orientation. S. O. Mast, The Johns Hopkins University.
- *47. Adaptation to light in *Euglena variabilis* (?) and its bearing on reversion in orientation. S. O. Mast, The Johns Hopkins University.
- *48. The maze-behavior of white rats in the second generation after alcoholic treatment. E. C. MacDowell and E. M. Vicari, Carnegie Institution of Washington.
- *49. The relation of modifiability of behavior and metabolism in land isopods. C. H. Abbott, Massachusetts Agricultural College, (from the Osborn Zoological Laboratory, Yale University; introduced by Henry Laurens).
- 50. The rate of carbon dioxide production by pieces of *Planaria* in relation to the theory of metabolic gradients. George Delwin Allen, University of Minnesota (introduced by E. J. Lund).

EVOLUTION

- *51. Irreversible differentiation and orthogenesis. C. Judson Herrick, University of Chicago.
- *52. An analysis of the sexual modifications of an appendage in sex-intergrade *Daphnia longispina*. A. M. Banta and Mary Gover, Station for Experimental Evolution.

COMPARATIVE ANATOMY

- *53. The Urodele vomer. Inez Whipple Wilder, Smith College.
- *54. The origin, function, and fate of the test-vesicles of *Amaroucium constellatum*. (Lantern.) Caswell Grave, Washington University.
- 55. Respiratory organs of *Ucides caudatus*, a West Indian land crab. (Lantern.) C. C. Nutting, University of Iowa.

- *56. The homologies and development of the palpal organ of male spiders. W. M. Barrows, Ohio State University.
- *57. Morphology of the enteron of the periodical cicada (*Tibicen septendecim* Linn). Chas. W. Harbitt and L. M. Hickernell, Syracuse University.
- *58. Sexual dimorphism in Nemerteans. W. R. Coe, Yale University.
- 59. The columella auris of the Reptilia. Edward L. Rice, Ohio Wesleyan University.
- *60. The spiracular sense organ of elasmobranch, ganoid, and dipnoan fishes. H. W. Norris and Sally P. Hughes, Grinnell College.

INVITATION PROGRAM

- 61. Faunal areas on the Pacific slope of South America. C. H. Eigenmann, University of Indiana.
(Discussion led by C. C. Nutting, University of Iowa.)
- 62. Polyembryony and sex. J. T. Patterson, Texas University.
(Discussion led by S. I. Kornhauser, Denison University.)
- 63. Physiological life histories of terrestrial animals. V. E. Shelford, Illinois Natural History Survey and the University of Illinois.
(Discussion led by Thomas Headlee, New Jersey Agriculture Experiment Station.)
- 64. The work of the National Research Council in relation to Zoology. C. E. McClung, Chairman, Division of Biology and Agriculture, National Research Council.
(Discussion from the floor by C. H. Eigenmann and T. D. A. Cockerell.)

PAPERS CONTRIBUTED BY THE ECOLOGICAL SOCIETY OF AMERICA

- 65. Hydrogen ion concentration in the different stages of pond succession. V. E. Shelford, Illinois Natural History Survey.
- 66. Distribution of life on a river bottom. A. D. Howard, U. S. Bureau of Fisheries.
- 67. Changes observed in river fauna above Keokuk Dam. A. D. Howard, U. S. Bureau of Fisheries.
- *68. Ecological succession of insects in stored food products. Royal N. Chapman, University of Minnesota.

PAPERS FOLLOWING THE ZOOLOGY DINNER

- 69. The Message of the Biologist, Vice-Presidential address for Section F. William Patten, Dartmouth College.
- 70. Motion pictures of the Barbadoes-Antigua Expedition. C. C. Nutting, University of Iowa.

EXHIBITS

1. Slides of stained cysts of the intestinal amoebas and flagellates of man (requires five microscopes with oil-immersion lenses). S. I. Kornhauser, Denison University.
2. Wire models of paths of oyster larvae, dero, etc. A. A. Schaeffer, University of Tennessee.
3. The embryonic columella auris of the lizard Eumeces. Edward L. Rice, Ohio Wesleyan University.
4. Phanotypes in coat colors in mice. J. A. Detlefsen and Elmer Roberts, Laboratory of Genetics, College of Agriculture, University of Illinois.
(Demonstration for cytology)
5. Demonstration of synapsis stages in the chromosomes of grouse locusts and other grasshoppers. W. R. B. Robertson, University of Kansas.
(Demonstration for genetics)
6. Feathers illustrating the inheritance of color in varieties of the domestic turkey. W. R. B. Robertson, University of Kansas.
7. The development of the asexual larvae in Paracopidosomopsis. J. T. Patterson, University of Texas.

ABSTRACTS

EMBRYOLOGY

1. *The individuality of the germ-nuclei during the cleavage of the egg of Cryptobranchus alleghehiensis.* BERTRAM G. SMITH, Michigan State Normal College.

In the fertilization of the egg of *Cryptobranchus alleghehiensis* the germ-nuclei do not fuse, and in the first cleavage mitosis each gives rise to a separate group of chromosomes whose descendants pass separately to the daughter-nuclei. During the ensuing resting stage each germ-nucleus is represented by a structurally distinct vesicle. The separate-ness of the germ-nuclei is thus maintained throughout the entire nuclear cycle. Throughout early cleavage the nuclear divisions are of the same duplex type, and the resting nuclei are always distinctly double. The genetic continuity of each half of the double nucleus has been clearly traced to an advanced cleavage stage. During late cleavage and in the early gastrula the nuclei are still typically double, but certain irregularities which tend to disguise the double structure occur with increasing frequency and the segregation of the maternal and paternal chromatin cannot always be demonstrated. The hypothesis of individuality of the germ-nuclei as applied to those species in which there is a mingling of maternal and paternal chromosomes is discussed, and supported by considerations regarding the persistent individuality of the chromosomes. The complete paper will appear in the *Biological Bulletin*.

2. *A sex intergrade pig, which resembles a free-martin.* WILL SCOTT, Indiana University.

This pig is full term and has the external genitalia of a female. In addition, a scrotum is developed. Internally a vagina and uterus are formed, but the gonad has migrated and degenerated. The position of the ducts has been modified correlative to that of the gonad.

3. *Retention of dead fetuses in utero and its bearing on the problems of superfetation and superfecundation.* ALBERT KUNTZ, St. Louis University, School of Medicine.

Two cases in the cat and one in the dog are described in which fetuses differing markedly in size and degree of development occupied the uterus contemporaneously. Evidence is presented which shows that in all of these cases the ova which gave rise both to the larger and the smaller fetuses were extruded at the same period of ovulation and were fertilized and implanted approximately at the same time. The smaller fetuses were retained in the uterus as dead bodies long enough to account for the difference in size and degree of development of the larger and

the smaller fetuses. Inasmuch as dead fetuses may be retained in the uterus for relatively long periods without undergoing extensive autolysis and absorption, it is suggested that in the majority of the cases reported in which fetuses differing markedly in size and degree of development occupied the uterus contemporaneously, the conclusion either that superfetation or superfecundation has occurred is unwarranted.

4. *An explanation of the early development of the peripheral nervous system in the vertebrate embryo.* H. H. LANE, University of Oklahoma.

It is well known that the chief nerve trunks are all laid down, together with most or all their important branches, before it is possible that distinctly nervous functions can be present, or if possible before they are of any conceivable importance to the embryo. In the rat fetus of 23 mm. length both the vestibular and cochlear nerves are well developed though the function of hearing is not established until about the twelfth day after birth. In the 16-mm. fetus the vibrissae have not yet emerged from the epidermis of the snout, yet the maxillaris and mandibularis branches of the trigeminus are well formed.

This early establishment of the peripheral connections of nerves receives its proximate explanation in certain well-known mechanical relations that exist only at an early stage in embryonic development. According to Harrison's experiments on the cultivation of tissues in vitro, each neurone sends out its axone in a predetermined manner and direction to the distance of a millimeter or a little more, a distance sufficient at an early stage in embryonic development for it to reach from the center of origin to the muscle fiber or epithelium with which it ultimately connects. That this activity must take place early in embryonic life is explained by the fact that it is only in these stages that the neuroblasts of the neural tube lie within the specified distance of a millimeter or so from the parts they are destined to innervate. That is to say, within the distance through which free growth of a nerve process is possible.

5. *The thyroid and parathyroid glands of Bufo tadpoles deprived of the pituitary glands.* BENNET M. ALLEN, University of Kansas.

The pituitaryless tadpoles used in this work were killed six months after the operation and more than four months after the metamorphosis of the controls. They range in size from 10 to 18 mm. in body length, the largest thus reaching a length almost one-third greater than that of recently metamorphosed tadpoles. Roughly speaking, the thyroid glands in these pituitaryless tadpoles show the same proportion to body size that is exhibited by the thyroid glands of normal tadpoles in a corresponding stage of differentiation. The thyroid glands of these pituitaryless tadpoles reach only one-third the actual size attained by the thyroid glands of normal Bufo at metamorphosis. Solid colloid masses develop in the follicles. These increase in size with the growth of the tadpole, and with the corresponding growth of the thyroid gland. The parathyroid glands, on the other hand, reach unusual size, approaching

that found in the thyroidless tadpoles of corresponding size, growing to a size not only relatively greater than that in the normal *Bufo* at the completion of metamorphosis, but exceeding the size of the parathyroids of young toads killed long after metamorphosis and with a body length one-third greater than that of the larger pituitaryless tadpoles. In specimens from which both the pituitary and thyroid glands have been removed, the parathyroid glands appear to have undergone growth equal to that shown when either gland is removed; but the material is not extensive enough to detect possible slight differences.

6. *The influence of thyroid extirpation upon the various organs of Bufo larvae.* BENNET M. ALLEN, University of Kansas.

In earlier papers, the author has rather cautiously claimed that removal of the thyroid glands of *Rana* produces a cessation in the differentiation of the somatic structures, while not affecting the development of the germ cells and gonads except as limits are placed upon them through size and nutritional factors. Considerable evidence has been advanced by my students and myself upon this point. Verification of these statements as demonstrated in *Bufo* is not stated in this abstract, except to say that this work substantiates the conclusions drawn from the earlier studies upon *Rana*.

The various organs studied roughly show the structural characteristics found in normal tadpoles of the corresponding stage of differentiation as judged by external features. This is shown in the presence of epidermal teeth, absence of the tongue, the lack of differentiation of the stomach, the length of the intestine, character of the large intestine, and the form of liver and pancreas. The pronephros persists and the bladder remains rudimentary. The oviduct fails to develop in the thyroidless tadpoles, while it has passed through the early stages of development in the much younger and smaller metamorphosed toads. The germ glands develop slowly in *Bufo*, so that it is not so favorable a form as *Rana* for the study of this feature. However, the germ glands are not only actually, but relatively larger and further advanced in development in the giant thyroidless tadpoles than in the much younger metamorphosed controls.

7. *Stages in the development of the thymus, parathyroid and ultimobranchial bodies in turtles.* CHARLES EUGENE JOHNSON, University of Kansas.

In turtles, with special reference to *Chelydra*, *Chrysemis*, and *Trionyx*, the thymus arises from the third and fifth visceral pouches, the portion contributed by the fifth pouch being considerably smaller than that developed from the third pouch.

The third visceral pouch also gives origin to a parathyroid body, but such is not the case, at least as a rule, with the fifth pouch.

The fourth and fifth pouches and the diverticulum which gives rise to the ultimobranchial body are at first included in a single evagination from the lateral wall of the pharynx, just behind the third visceral

pouch. From this evagination the two pouches and the ultimobranchial pocket are then differentiated as secondary outgrowths, the fourth pouch alone forming an anterior division and the ultimobranchial pocket making up the major portion of a posterior division, while the fifth pouch appears as a rather small lateral outgrowth from the proximal portion of the latter.

The third pouch attains considerable size and develops a cleft of short duration. Following its separation from the ectoderm and the endoderm, the pouch remains for a time as an epithelial vesicle before its further transformation—into a thymus body in its anterior part and a parathyroid in the caudal portion.

After the fourth pouch has become separated off from them, the fifth pouch and the ultimobranchial pocket become disconnected as a unit from gut wall and surface ectoderm. The ultimobranchial part increases rapidly in size and, especially in *Chelydra*, attains relatively enormous proportions. It may also present as offshoots smaller vesicles of varying size and form. The fifth pouch is probably transformed from a vesicle into a thymus body, but for a longer or shorter period during this phase of its development it remains attached to the ultimobranchial vesicle.

In its early stages the ultimobranchial diverticulum is nearly equally well developed on right and left sides of the body, but that of the right side soon lags behind and, as a rule, attains only relatively small size. To what extent it may form a persisting ultimobranchial body has not at the present time been determined.

8. *The results of the extirpation of the thyroid and of the pituitary anlagen on the interrenal tissue in Rana pipiens.* ALICE L. BROWN, Kansas State Agricultural College. (Introduced by B. M. Allen.)

Microscopic serial section examination of the mesonephroi of thyroidless larvae reared to the ages of 12, 15, 18, 27 and 30 months show irregular, definite interrenal tissue masses about the renal vein. Scattered through the interrenal tissue of the 18-, 27-, and 30-months larvae appear definite chrome-brown cells.

Even a 27-month pituitaryless larva shows indefinite interrenal tissue masses about the renal vein.

Serial camera-lucida sketches of the 27-month thyroidless larva compared with those of the 27-month pituitaryless larva present larger definite masses of interrenal tissue in the thyroidless larva.

In all thyroidless and pituitaryless larvae examined the interrenal tissue occupies a larval position in relation to the mesonephroi, namely, irregular masses about the renal blood-vessel.

CYTOLOGY

9. *The effect of hypotonic and hypertonic solutions on fibroblasts of the embryonic chick heart in vitro.* M. J. HOGUE, School of Hygiene and Public Health, Johns Hopkins University.

Pieces of embryonic chick heart were grown in Locke-Lewis solution made hypertonic by boiling and hypotonic by adding distilled water. Normal growths in Locke-Lewis were also treated with these solutions and the individual cell was studied.

The hypotonic solutions contained 0.54, 0.45, 0.3, and 0.225 per cent NaCl. Tissues grew in the first two solutions, which acted as a stimulus. They did not live as long in these as in normal Locke-Lewis. The cells absorbed much water, as did also the nucleus, which frequently formed a nuclear vacuole as an outlet for the extra amount of liquid absorbed. Neutral red vacuoles and granules soon lost their color when treated with the hypotonic solutions that caused the death of the cells. Mitochondria were not effected by the hypotonic solutions, but as the cell died, either vesicles formed at their extremities and persisted after the rest of the mitochondrium had disappeared, or the mitochondrium broke up into granules, or simply became more slender until only a faint, rough line was visible.

Hypertonic solutions with 1.2, 1.5, and 1.8 per cent NaCl were used. The cells grew in the first two solutions. When cells of normal growth were treated with these solutions, they often contracted, leaving many long slender processes which were later withdrawn. Occasionally these fibrils moved and anastomosed with other fibrils, becoming real connective-tissue fibrils. The cytoplasm frequently became alveolar when death processes set in. Neutral red channels sometimes formed.

10. *Coelenterates and the evolution of germ cells.* GEORGE T. HARGITT, Syracuse University.

In the Hydrozoa the observations upon germ-cell origin and segregation, budding, regeneration, and development from dissociated cells have led to the following conclusions: All cells of the body (except possibly the netting and nerve cells) are capable of further differentiation in various directions. This includes the power of dedifferentiation and of specialization in a new direction. There cannot be, therefore, any real distinction between body cells and germ cells.

Specialized cells of other adult animals (including vertebrates) show, in varying degrees, the power of dedifferentiation and new specialization. The capacity for specialization in different directions is universally present in the cells of embryos or of larvae, and sometimes throughout the youthful stages. But there is a time in ontogeny when further specialization of cells involves the loss of capacity for any new differentiation; this is the period at which germ cells are usually segregated into a distinct tissue. In the higher organisms this may occur early in ontogeny, in Hydrozoa it never occurs.

11. *Cytological criteria for the determination of amoebic cysts in man.* (Lantern.) SIDNEY I. KORNHAUSER, Denison University.

For the distinguishing of the harmful *Endamoeba dysenteriae* of man from the other two common intestinal amoebas, *Endamoeba nana* and *Endamoeba coli*, the encysted stage offers better criteria than does

the active stage. No one characteristic can be relied on as being absolutely diagnostic in all cases; therefore minute and very careful cytological examination, using three methods, was employed. An examination of fresh material in iodine-eosin reveals the character of the cytoplasm, the presence and distribution of the glycogen mass and the form and number of the nuclei. It also allows one to distinguish readily true cysts from yeasts and spores. An examination of fresh material in Janus-green shows the form of the chromatoid bodies, which stain as do mitochondria in metazoan cells. Thirdly, wet smears were fixed and stained in iron haematoxylin and treated just as sections for cytological study. Examination of cysts in these preparations with oil-immersion lens furnishes absolute and definite criteria. The number of the nuclei, the distribution of the chromatin within the nuclei, and the size, number, and character of the chromatoid matter can readily be determined. These same methods also allow one to distinguish the cysts of intestinal flagellates. Thus cytoplasmic as well as nuclear characteristics furnish the basis for diagnosis, whereas the size of the cysts is not a good criterion.

12. *The spermatogenesis of Anolis carolinensis.* THEOPHILUS S. PAINTER, The University of Texas.

The spermatogenesis of reptiles has not received the attention of cytologists heretofore, although the position of the group in the Vertebrate Series and especially the peculiar behavior of the chromosomes as reported for the birds and mammals, make such a study very desirable. The author has been making a comparative study of the spermatogenesis of the lizards, common near Austin, Texas. *Anolis carolinensis*, the 'American chameleon,' has yielded preparations in which the chromosomes show up with clear-cut distinctness, and it has been possible to follow practically all of the chromosomes from the spermatogonial divisions to the formation of the mature sperm. Two points of especial interest have been found.

What appears to be a typical 'accessory' or sex-chromosome is found in the first maturation division; it is bipartite in character and goes undivided to one pole of the spindle. In the second maturation division, the sex-chromosome, when present, divides. The sperm are dimorphic as regards the sex-chromosome, half are with and half are without this body. There is no trace of degenerating sperm.

The autosome complex of *Anolis* consists of ten large chromosomes and twenty-two smaller bodies. (This condition, a few large chromosomes and a greater number of small chromosomes seems typical for all the lizards studied.) The autosomes behave normally during maturation. In the first and second spermatocyte divisions five large and eleven small chromosomes are seen (in addition to the sex-chromosome) and these divide in the usual way. There is no sign of a 'double reduction,' such as has been reported for birds and some mammals. In this reptile, the chromosomes differ in no essential respect from what is found in the insects and other invertebrates.

13. *The presence of a longitudinal split in chromosomes prior to their union in parasynapsis.* W. R. B. ROBERTSON, University of Kansas.

It is usually stated in accounts of the synapsis stages that, following the telophases of the last spermatogonial division, a series of changes takes place which results eventually in the formation of fine single threads (leptotene stage), that pair in the succeeding diplotene. The chromosomes of *Tettigidae* of which there are thirteen (♂) exhibit a longitudinal split in each member during the telophase and post-telophase stages previous to parasynapsis. Following the stages in which there are thirteen split chromosomes come those in which the twelve autosomes of the group pair side by side to form six threads, each of which is probably a four-strand structure—a future tetrad. The plane of this presynapsis split in the members of a pair probably coincides to a large extent with one of the planes of division in the succeeding tetrad.

The telophases of somatic mitoses likewise show their chromosomes to be split before entering the so-called resting condition. The split in a telophase chromosome of either a somatic or spermatogonial cell-division probably dates to the resting period previous to the division just being completed.

The presynapsis splitting of each conjugating chromosome may account for the peculiar twisting sometimes visible in the two strands of one of the conjugants as compared with those of the other in long or V-shaped tetrads. The possibility of such independent twisting may have something to do with the mechanics of 'crossing-over.'

14. *Chromosome studies in Tettigidae. II. Chromosomes of BB, CC, and the hybrid BC in the genus Paratettix.* MARY T. HARMAN, Zoölogy Department, Kansas State Agricultural College.

BB, CC, and their hybrid BC (Nabours, '14 and '17) are the only forms considered in this paper. Six pairs and an unpaired chromosome are present in the spermatogonia. In BB the chromosomes of the third pair, according to size, taper toward one end and are bent so as to have almost the appearance of a hook. In CC the chromosomes of this pair are nearly oval. In the hybrid, BC, this pair of chromosomes is composed of an oval chromosome like in CC and a bent chromosome like in BB. The difference in this homologous pair of chromosomes is recognized at the end of the growth period previous to the formation of the chromosomes of the first maturation spindle.

The diploid number of chromosomes appear at the end of the growth period previous to the formation of the bivalent chromosomes. The bivalent chromosomes are formed by an end-to-end union of the homologous pairs of these chromosomes before they have been completely condensed. The sex chromosome may be recognized at all stages.

In the first maturation division the bivalent chromosomes separate at the line of union and the sex chromosome goes to one pole undivided. The formation of the diploid number of chromosomes at the end of the growth period and the union, end to end, of their homologous pairs may explain the absence of any crossing-over in *Paratettix*.

PARASITOLOGY

15. *Notes on the life-cycle of two species of Acanthocephala from freshwater fishes.* H. J. VAN CLEAVE, University of Illinois.

The complete life-cycle is not known for a single typically North American species of Acanthocephala. Several investigators have collected specimens and data pertaining to the development of two important fish parasites belonging to this group and submitted them to the writer for study. Dr. A. R. Cooper found *Pontoporeia* sp. abundant in the stomachs of whitefish which were heavily infested with *Echinorhynchus coregoni* Linkins. The body cavity of some of the amphipods taken from the stomach contained fully formed larvae of *E. coregoni*. Stages in development between the hard-shelled embryo within the cavity of the gravid female and the larva ready to infect the definitive host have not been found.

Larvae encountered by Director A. F. Shira in *Hyalella* sp. obviously belong to the species *Echinorhynchus thecatus* Linton. Young small-mouthed black bass which were fed upon *Hyalella* carrying these larvae developed a heavy infestation of *E. thecatus*. Encysted larvae of the same species were found in the peritoneum of *Perca flavescens* by Dr. A. S. Pearse and in cysts from the viscera of *Micropterus salmoides*, *Ambloplites rupestris*, and *Percina caprodes* by Dr. George R. LaRue. It seems probable that *Hyalella* serves *E. thecatus* as a primary host, and that in development a vertebrate intermediate host may be interpolated between the primary and definitive hosts of this parasite.

Investigators in other branches of zoology may greatly facilitate the work upon life-histories of parasitic forms of economic importance by making their incidental and accidental observations upon larval stages of parasites known to some one interested in the group in question.

16. *On the life-history of the gape-worm (Syngamus trachealis).* B. H. RANSOM, U. S. Bureau of Animal Industry, Washington, D. C.

Adult turkeys commonly harbor gape-worms, adult chickens only very rarely. Out of 679 turkeys from Center Market, Washington, D. C., 22.5 per cent were infested, but none of 635 chickens from the same market harbored this parasite. Full-grown turkeys and young chickens may be readily infected with gape-worms by feeding them the infective stage. Full-grown chickens, however, are very resistant to infection, and the parasites when they do succeed in developing in adult chickens apparently are able to survive only for a brief period after they reach maturity and commonly succumb before reaching full development.

As sources of infection to young chickens, adult turkeys are highly important, but adult chickens appear to be of little importance as carriers of gape-worms. Infection may persist in the soil for a long time, as the eggs and larvae of gape-worms have been kept alive in moist media for over 8 months and at a temperature of about 50° F.

When gape-worm eggs containing larvae in the infective stage are fed to chickens, the young worms may be found in the lungs within a week. The two sexes become coupled in the lungs while the worms are still very small (2.25 mm. long). They afterward move forward into the trachea, the females reaching maturity and beginning to deposit eggs as early as two weeks after the eggs from which they developed were swallowed, attaining a length of about 15 mm. during this period. In guinea-pigs gape-worms are able to undergo an imperfect development.

17. *A new bladder fluke from the frog.* JOHN E. GUBERLET, Oklahoma Agricultural Experiment Station, Stillwater, Okla.

A species of Trematode was observed in the urinary bladder of the bullfrog (*Rana catesbiana*) in Oklahoma. Studies upon this form showed it to be an undescribed species of *Gorgodera*. I wish to propose the name *Gorgodera circava*.

This form is firmly attached to the wall of the bladder by the ventral sucker. The anterior region of the body is very active and moves about freely while the posterior portion is less active, but not sluggish. The anterior region of the body is cylindrical, while the posterior part is somewhat flattened and rather opaque. The length of the animal varies from 2.5 to 3.75 mm. with a breadth of 0.5 to 0.65 mm. The acetabulum is 1.8 to 2.4 times the size of the oral sucker. The acetabulum is surrounded by a distinct circular sheath which produces a space of from 0.051 to 0.135 mm. in width around the acetabulum. This structure is a distinct characteristic of this species.

The ovary is a distinct three-lobed structure posterior to the acetabulum and occurring on either the right or left side. Immediately in front of it are the vitellaria composed of two lobes of six to eight follicles each. Dorsal to the acetabulum is the large vesicula seminalis, and from its anterior end the ejaculatory duct passes anteriorly and ventrally to the genital pore. The lower portion of the ejaculatory duct is surrounded by the prostate glands and is much enlarged, forming a spacious lumen in this region. The eggs are 0.030 by 0.023 mm. in size.

18. *Studies on the development of Ascaridia perspicillum, parasitic in fowls.* JAMES E. ACKERT, Kansas State Agricultural College.

An important parasite of chickens is the nematode, *Ascaridia perspicillum*, which matures in the small intestine. Examinations of 424 local fowls revealed infestations in 42.4 per cent of them, thirty or more worms usually making a visible effect upon the fowl, and frequently causing its death. These helminths are dioecious, and the presence of more than 1200 fertilized eggs in a female indicates their prolificacy. Segmentation normally begins when the eggs are emitted from the worm, and when incubated at 28°C. the larvae are fully formed in nine days. While an occasional larva escapes from the egg in the culture medium, the normal place of hatching apparently is the digestive tract of the chicken.

Within twenty-eight hours after the ingestion of eggs containing motile larvae, the fowl's small intestine is filled with young active nematodes, which besides breaking through the shell have increased their length 25 per cent. A three-day sojourn in the chick's intestine enables the larvae to double their length, whereas after thirty days in the body of the fowl these helminths are nearly half grown. To date, a single larva has been found in the lung and one in the trachea.

That the ova of this species are somewhat resistant to extremes of humidity and temperature is indicated by their continuous development through at least seven days' exposure to the sun in June and July at temperatures of 23°C. to 33°C., and by their ability to endure fifteen hours of continuous freezing at temperatures between -11.6°C. and -8°C.

19. *New data bearing on the life history of Sarcocystis tenella.* JOHN W. SCOTT, University of Wyoming.

Numerous theories have been put forward to account for the life histories of the muscle parasites of the herbivorous animals. As the result of experiments in transmitting the parasite we now know with a good degree of certainty the general nature of the life history of *Sarcocystis tenella*, and without serious doubt this will hold true of the life histories of the muscle parasites of herbivorous animals in general. Lambs with ewes have been raised until killed in a screened cage which, except for a few small transient gnats, was kept insect-free during the entire time. A cement foundation extending some distance below the surface prevented the ingress of mice or any other animals that might serve as hosts of the parasite. Nevertheless infection of the lambs took place. From this experiment it would seem that Darling's theory that certain insects serve as necessary hosts of this parasite is no longer tenable. Likewise, the theory that a carnivorous animal acts as a necessary intermediate host will have to be discarded. Other experiments indicate that the life cycle is a direct one and that infection takes place by means of food recently contaminated with fresh feces from an infected sheep or lamb. This being correct there would appear to be present in the intestine of the host a hitherto scarcely suspected, and probably sexual, stage of the parasite. The life history of *S. tenella* therefore probably agrees closely with that of *S. muris*, as worked out by Smith, Nègre, Erdmann, Crawley, and others. Consequently, so far as we know, the life histories of all muscle parasites appear to be similar and involve in each case only one necessary host.

20. *Contributions to the Life History of Gordius robustus* Leidy. H. G. MAY, Mississippi College.

Gordius robustus is parasitic in several species of Locustidae. Hosts were infected in the laboratory and all stages of the parasite were obtained.

There is no complicated metamorphosis, but the larval cuticula together with the hooks of the proboscis are shed at the end of the parasitic period.

The adult cuticula is formed by the differentiation of parts of the hypoderm cells, and the bristles are part of the fibrous cuticula.

The intestine is never open at the anterior end.

The muscles and parenchyma are derived from mesenchyme cells. The muscle cells form a lining of the hypoderm, elongate, and become flattened, forming contractile fibrils within the cell body. The parenchyma cells form a solid mass filling nearly every space in the body. The parenchyma does not form a special layer around the ovaries and consequently no mesenteries are produced. The cells produce their heavy walls late in development. The cloacal musculature consists of cells intermediate between true muscle cells and parenchyma cells.

The nerve cord is derived from two rows of cells in the larva which enlarge and pass inward. The brain is derived from a ring of cells in the base of the proboscis.

The gonads appear as two rows of cells dorsal to the intestine and grow into solid strands of cells not covered by epithelium. They remain such in the males, but in the females produce buds on the ventral side; the eggs later passing entirely out of the original ovarian tubes into these large buds or pockets.

21. *Leucochloridium problematicum*, N. Sp. THOMAS BYRD MAGATH
Mayo Clinic, Rochester, Minnesota.

Leucochloridium problematicum, n. sp. was found in *Planorbis trivolvis* and *Succinea retusa* in Fairport, Iowa, in the summer of 1917. This is the first description given of a species of this genus in America and the second larval form to be described within the genus.

The sporocysts are 1.4 cm. long and 0.33 cm. wide, pointed at both ends. The mature one projects from the tentacle of the snail and is connected to other immature ones which are in the liver of the host. The mature sporocyst is capable of pulsation, has a thick wall and is white and translucent. The distal half of the sporocyst is banded with deep golden red bands which are not all of the same depth of color. The lighter ones tend to be more golden. No bands appear on the distal half, while the proximal one fourth is flecked with small golden spots. This sporocyst differs markedly from the sporocyst of *L. macrostomum* found in Europe.

The larvae themselves, of which there are about 100 in a sporocyst, are 2.2 mm. long and 0.85 mm. wide. They have both an oral and ventral sucker. Detailed description of the organ systems is given in the paper but in general the organs are quite characteristic of the genus *Leucochloridium*. The ovary lies between the two testes and the cirrus sac is ovoid in shape. An interesting feature is the fact that the Laurer's canal in this species opens in the excretory duct near the excretory pore.

From a study of the adult species reported in this genus, of which there are only three, it becomes evident that there is a marked similarity between this new species and the species *L. insignis* of Looss. This Egyptian species in turn is not unlike the species *L. ceratum* of Monticelli and it may be that *L. problematicum* is the larval form of one or both of these worms, although the author does not feel warranted in this conclusion at the present time.

Note: This paper will appear in the Journal of Parasitology as a contribution from the Laboratory of the United States Bureau of Fisheries, Fairport, Iowa, and the Mayo Clinic, Rochester, Minn.

22. *Two new genera of Acanthocephala from Venezuelan fishes.* H. J. VAN CLEAVE, University of Illinois.

Practically nothing has been published dealing with the Acanthocephala of South American fishes since the work of K. M. Diesing ('51). He described a few species from Brazilian fishes, but no successful attempt has been made to include his species from fishes in the fairly recently developed system of classification for this group of parasites. His brief descriptions and generalized figures suggest some interesting deviations from conditions found in better-known species.

The North American acanthocephalan fauna has been shown to differ radically from the European fauna upon which the modern system of classification has been based. It is not improbable that radical differences will also be found when the South American acanthocephalan fauna of fishes is more thoroughly investigated. A small collection taken from fishes of Lake Velencia in Venezuela by Dr. A. S. Pearse contains but two species of Acanthocephala, but each of these represents a new genus. Numerous problems regarding relationships of families and of genera of these parasites are suggested by the study of these new materials.

The new genus *Pandosentis* belongs to the *Neoechinorhynchidae*. It possesses characters which suggest closer relationship to the two North American genera *Gracilisentis* and *Tanaorhamphus* than to the type genus of the family.

The new genus *Quadrigyrus*, through the body spines, shows an evident relationship to the *Rhadinorhynchinae*, but the proboscis hooks and the structure of the proboscis receptacle suggest a possible affinity with the *Neoechinorhynchidae*.

23. *Note on behavior of embryos of the fringed tapeworm.* JOHN W. SCOTT, University of Wyoming.

Hexacanth embryos of *Thysanosoma actinoides* recently escaped from the egg capsule show some movements of peculiar interest. The nature of these movements is described in considerable detail. The significance of the boring movements appears to be of teleological importance considering the fact that the complete life history of this tapeworm is not known; at least the movements would suggest that

the embryo reaches the inside of the intermediate host by active movements rather than passively as has been generally supposed.

24. *Contributions to the life history of Paragordius varius* (Leidy).

G. H. MAY, Mississippi College.

Paragordius varius is parasitic in crickets. Infection in the laboratory was not successful, but practically all stages of development were found in hosts infected in nature. Development is essentially the same as in *Gordius robustus*.

The bristles are structures of the homogeneous layer of the adult cuticula and not of the fibrous layer.

The intestine remains connected at the anterior end to a cord of cells leading in the larva from the stilets of the proboscis to the partition between the proboscis and body. These cells undergo slight development, but later die and disintegrate, leaving an opening from the end of the intestine to the larval cuticula at the anterior end. As a result the intestine obtains an anterior opening to the surface at the time the larval cuticula is shed.

The ovaries are surrounded by parenchyma. With the formation of the buds this layer is extended from the dorsal side of the body to the ventral side, a layer passing on either side of the intestine, from there around an ovarian bud to the dorsal side, and down to the point of origin about two-thirds of the diameter of the body from the dorsal side. This layer of mesenchyme then becomes attached to a layer lining the muscle cells and remains as a distinct layer only on the inner side of the ovary. In that way arise the double mesenteries described in text books and entirely absent in *Gordius robustus*.

GENETICS

25. *Selection for increased and decreased bristle number in the mutant strain 'reduced.'* F. PAYNE, Indiana University.

In the seventh generation of the strain selected for extra bristle number appeared a male with one bristle on the scutellum. When out-crossed to wild this reduced condition of the bristle number behaved as a sex-linked character. The number of bristles in this mutant line varied from zero to four. Minus and plus selection lines were started and carried for sixty-four and sixty generations, respectively. Toward the end of the experiment the percentage of zero flies in the minus line varied from 96 to 100. A pure line with no bristles was not produced. In the plus line the percentage of flies with four bristles (this is the normal number) reached 64.25 in the fifty-fifth generation. There were very few flies with one and no bristles. The two lines were widely different at the end of the experiment. They came originally from the same pair of parents. How do they differ genetically, is the question. By means of linkage it was shown that there are at least two factors and probably a third concerned in the production of bristles in the plus

line. Two of these factors are sex-linked. If there is a third present, it is in the third chromosome. In the minus strain only a single factor is present.

26. *The mutational series, full to bar to ultra bar, in Drosophila.* CHARLES ZELENY, University of Illinois.

Ultra-bar appeared in a single male in the second generation of downward selection in white bar on November 20, 1917. The stock established from it averaged 23 facets in the males as opposed to 75.6 facets in the bar stock from which it was derived and 849.8 facets in full eye. It has remained constant since that time except for the appearance of a few additional mutations. The interest in this mutant lies in the following facts. It is not due to an accessory factor, but is a change in the bar gene itself. The changed gene produces a somatic effect which is an intensification of that produced by bar. This effect is in the direction of selection. The dominance is greatly increased. Ultra-bar and the various other races of bar furnish unusual material for a quantitative study of both germinal and environmental factors.

27. *Variation in the percentage of crossovers and selection in Drosophila melanogaster.* J. A. DETLEFSEN and E. ROBERTS, College of Agriculture, University of Illinois.

Series A. Long-winged red-eyed F_1 females heterozygous in miniature wing and white eye were mated in pairs to their miniature-winged white-eyed F_1 brothers. The F_2 offspring of the F_1 female showing the lowest percentage of crossover were selected and mated. Continued inbreeding and selection gave a stock showing about 0 per cent crossovers at the end of ten generations, as compared with 33 per cent at the beginning of the experiment. This stock bred en masse for six more generations continued to give about 0 per cent crossovers. For example, in the F_{15} we obtained two crossovers in a total of 977.

Series B. The same experiment was begun a year later with stock entirely unrelated to that of series A. Inbreeding and selection were continued for twenty-eight generations and gave a stock showing 5 per cent crossovers, as compared with the normal 33 per cent at the beginning of the experiment. The stock has bred true to about 5 per cent crossovers for ten generations.

Decrease in percentage of crossover has been accompanied by the increased appearance of non-disjunctional females. Tentatively, we have concluded that selection has increased the amount of heterosynapsis which would thus prevent the appearance of crossover classes.

28. *Inheritance of color in the domestic turkey.* W. R. B. ROBERTSON, University of Kansas.

The 'bronze' variety is characterized by much black in the feathers. In the wing primaries and secondaries there is an alternate banding of black with white in the tail of black with brown.

The 'bourbon red' variety is of an auburn color generally. The amount of black in the feathers is limited to a narrow black terminal band in the region of the breast, body, and thigh (on the male) and a few scattered dark granules in what would otherwise be black bands in such as tail coverts in the 'bronze.' Wing primaries and secondaries are white.

In reciprocal crosses of 'bronze' by 'bourbon red' the F_1 offspring are intermediate in color. Black bars in the tail are reduced in width and brown bars correspondingly increased. Feather tips are brownish white, not white. In the primaries the white bars are reduced and irregular or absent and the black more dilute. In the secondaries the dark bars are indistinctly outlined by a sprinkling of brownish black on a light bourbon-red-colored background. White bars are indicated by lighter areas.

In F_2 25 per cent are 'bronze,' 50 per cent are intermediate like F_1 , and 25 per cent are like the 'bourbon red.' Back crosses of F_1 by either parent give 50 per cent like F_1 and 50 per cent like the parent concerned.

Reciprocal crosses of black with 'bronze' show black to be dominant and to differ from 'bronze' by one unit character.

29. *Heredity of orange eye color.* F. PAYNE and MARGARET DENNY, Indiana University.

Orange appeared in the mutant strain 'reduced.' When mated to wild, three kinds of males appeared in F_2 . They were red, orange, and a new one called 'salmon.' From this it seemed that orange was due to two factors, and that they crossed over in F_1 . One of these factors by itself produced salmon, the other produced no visible effects. We shall call this second factor 'salmon modifier.' Experiments were devised to test this hypothesis. If crossing-over occurs between salmon and salmon modifier in F_1 , then some of the F_2 red males should carry salmon modifier. These were tested by mating to pure-line salmon females. If crossing-over occurs in F_1 of this cross, salmon and salmon modifier should occasionally get into the same chromosome, and hence orange males should appear in F_2 . They do occur, and hence the assumption is justified.

The above outlines the behavior of orange when mated to wild. When mated to reduced, however, no crossing-over occurs in F_1 , and hence only orange and red males appear in F_2 . Presumably a non-cross-over factor is present in the reduced strain which prevents crossing-over between salmon and salmon modifier. This has not been sufficiently analyzed to report further.

30. *The tabulation of factorial values for eye-facet number in the bar races of Drosophila.* CHARLES ZELENY, University of Illinois.

In working up the data obtained in a study of the germinal and environmental factors affecting eye-facet number in the bar races of *Drosophila*, it became evident that the demands of biological analysis were not adequately met by the system of arrangement in classes with equal

facet numbers. It has been shown by Krafka that the effect of temperature upon the mean facet value of a stock is approximately proportional to the mean value of that stock. A change of one degree in temperature in a 200-facet stock produces ten times as much change in facet value as it does in a 20-facet stock. The probability that other factors affecting facet number may act in a similar way is discussed, and the conclusion is reached that a tabulation in classes with equal facet numbers does not give as close an approximation to true factorial values as a tabulation in which the range of each class is equal to a definite fixed per cent of the mean facet value of its class. In the latter case the classes may be taken to represent equal factorial values, though the facet ranges are unequal. The variation constants can then be put directly in factorial units. Such a scheme is especially valuable in the graphic representation of selection data in which the mean of the unselected stock is taken as the point of departure, and any facet value can be represented as plus or minus a certain number of factorial units from the mean of the unselected stock.

31. *Linkage of genetic factors in mice.* J. A. DETLEFSEN and E. ROBERTS, College of Agriculture, University of Illinois.

Data were obtained to throw light on seventeen of the possible twenty-one linkage relationships which may exist between any two of the following seven allelomorphic pairs: agouti vs. its absence, black vs. brown, dark eye vs. pink eye, self vs. recessive spotting, dominant spotting vs. its absence, normal gait vs. waltzing, and color vs. albinism. In all cases except those involving either black, or dark-eye, or self with normal gait, the hybrids were mated back to the ultimate recessive to obtain data in the most advantageous form for disclosing linkage. In the exceptional cases the F_1 generation was mated inter se. As a test against simple Mendelian recombination, sixteen of the seventeen cases showed no wide deviations, and thus rule out any linkage except of such a loose nature that enormous numbers would be required to show it, which, for practical purposes, is tantamount to no linkage. In the case of dark eye and color, a definite linkage was found, both when the F_1 was mated inter se and when back-crossed to the ultimate recessive. The latter case is the more reliable and shows 16.1 per cent crossovers in a total of 1449. The results from F_1 mated inter se giving a total of 768 agree tolerably well with this.

32. *Forty-two generations of selection for high- and low-facet number in the white bar-eyed race of Drosophila.* CHARLES ZELENY, University of Illinois.

Following the discovery of the pronounced effect of temperature upon eye-facet number in *Drosophila*, a careful control of that factor has made possible a better analysis of the results of selection than that obtained in the earlier work of Zeleny and Mattoon, May, and Zeleny. The present paper deals with forty-two generations of selection in a white-bar race. With accurate temperature control it is possible to

isolate the occasional mutants as they arise and to demonstrate that if they are not included in the series, selection ceases to be effective after three to five generations. Crosses between the high and low lines confirm the results of previous selections and show that the difference between high and low is in large part, if not wholly, due to accessory factors outside of the sex chromosome in which the bar gene is located. There is no evidence that variability of the bar gene is a factor in this effect, which is purely a matter of the sorting of differences existing in the stock at the beginning of selection. There is, however, no limit to the possibilities of selection if the occasional mutants are included in the series, and two at least of these, reversal to full and ultra-bar, have been shown to be changes in the bar gene itself.

33. On the inheritance of congenital cataract in dairy cattle. J. A. DETLEFSEN and W. W. YAPP.

A pure-bred Holstein-Frisian bull, R. T. H., was mated to unrelated cows and produced 93 normal F_1 offspring. His normal F_1 son, I. V. H., was mated to 32 normal F_1 sisters and half-sisters, giving 63 offspring, of which 8 (6 bulls + 2 heifers) showed well-defined congenital cataract. The sire, E. T. H., was also mated to 6 F_1 daughters, producing 7 offspring, of which 3 (1 bull + 2 heifers) were blind. If congenital cataract is a simple recessive character, then the sire and son should produce a population of which 12.5 per cent are blind. The total results, 70 offspring, of which 59 were normal and 11 were blind, agree tolerably well with the calculated expectation 61.25 normal plus 8.75 blind.

ECOLOGY AND GENERAL PHYSIOLOGY

34. Observations on the habits of the larval colonies of Pectinatella. STEPHEN R. WILLIAMS, Miami University.

The behavior of these colonies has been watched for the past three summers. The material was obtained from Black Channel, Sandusky Bay, July 26, 1917, and from Terwilliger's Pond on South Bass Island during the months of July, 1918, and July, 1919.

The balloon-shaped, ciliated colonies free themselves from the gelatinous mass of the adult, and after swimming about for a time, attach themselves by mucous secretions to any convenient surface, that facing downward, by choice.

The colonies, when attaching themselves, fasten on the less illuminated parts of the jar.

Laboratory conditions furnish no satisfactory food, and the attached colonies, unable to grow, retrogress. After the yolk supply is gone the polyps in a colony are reduced from four (the average number) successively to three, to two, to one before the colony entirely disappears. The latest persisting polyp appears to be normal and healthy until all the tissue of the other polyps of the colony has disappeared. Then its mucous attachment elongates, the animal drops off, disappears, and dies.

35. *Animal aggregations.* W. C. ALLEE, Lake Forest College.

Studies on the causes and effects of animal aggregations in the water isopod, *Asellus communis*, three species of land isopods and the brittle starfish, *Ophioderma brevispina*, show that in general bunching is most prevalent under adverse conditions and upon the absence of means of otherwise satisfying the normally positive thigmotactic reaction.

Of the single factors experimented upon, the tendency to collect in bunches is most strongly affected in *Asellus* by the breeding reactions; in the land isopods, by the amount of moisture present and in *Ophioderma* by the amount of light. In the isopods the bunching is also affected by light, temperature, and the duration of the bunched condition.

In all these animals there is a lowered rate of metabolism immediately following the formation of the aggregation as measured by oxygen consumption or carbon dioxide production. When isolated and bunched animals stand for long periods of time, the effect upon the metabolic rate is reversed, both have a lower rate than when first collected, but the decrease is greater in isolated than with bunched animals. In the land isopods this decrease in metabolic rate is accompanied by a greater loss of water by the isolated animals.

Under laboratory conditions the formation of aggregations serves to make these animals more quiet and in the long run proves to be what is usually called an adaptive reaction.

36. *Behavior of the larvae of Corethra punctipennis Say.* CHANCEY JUDAY, Wisconsin Natural History Survey.

Larvae of *Corethra punctipennis* Say are abundant in the deeper portions of Lake Mendota from November to April; more than thirty thousand per square meter have been noted. The larger larvae burrow into the muddy ooze at the bottom and remain there during the day. At night they leave the mud and occupy the water; some of them even come to the surface, thus showing a vertical migration of 25 meters in the deepest water. They emerge from the mud promptly in the evening, the great majority being found in the water about an hour after sunset. For a period of two months or more during the summer anaerobic conditions obtain in the muddy ooze which the larvae occupy in the daytime.

The pupae also occupy the mud in the daytime and migrate into the water at night.

For a time after hatching, estimated as one to two weeks, the small larvae occupy the lower water in the daytime instead of the mud, but they also migrate into the upper water at night. When they become one-third to one-half grown, they begin to show the same behavior as the full-grown larvae, secreting themselves in the mud in the daytime and emerging at night.

37. *Studies on Chitons.* W. J. CROZIER, Hull Zoölogical Laboratory, the University of Chicago.

1. Analysis of neuromuscular mechanisms. Through the action of strychnine it was possible to secure, in *Chaetopleura*, good evidence of reciprocal innervation, reversal of inhibition, etc., as with typical synaptic neuromuscular systems. Stimulation, under strychnine, leads to the strong contraction of extensor muscle groups, in both body and girdle. A curious 'reversal' of response to shading is also evident. Nicotine excites flexor muscle groups. Curare is practically without effect, a result quite different from that obtained with other molluscs, but affording an interesting parallel to the state of affairs in flatworms.

2. The functions of the shell-'eyes.' From studies of *Acanthochites*, *Chaetopleura*, *Chiton*, *Tonica*, and *Ischnochiton*, an attempt was made to discover the functional properties of the several kinds of tegumentary 'eyes' present on the shell-valves of different chitons, leading to the possibility of assigning a particular kind of photic irritability to each particular kind of structural element. The results are consistent with Nowikoff's suggestions regarding the evolution of the shell-eyes, and support, furthermore, the doctrine of receptor specificity.

38. *On the natural history of Onchidium.* LESLIE B. AREY, Northwestern University, and W. J. CROZIER, University of Chicago.

The quasi-marine pulmonates of the *Onchidium* group have in the past been notable for the puzzling features of their somewhat obscure morphology. For the first time a fairly comprehensive study is now provided of the no less remarkable activities of these snails. The completed report, shortly to be published, deals systematically with the ordinary movements and sensory responses of *Onchidium floridanum*, and especially with the analysis of its photic responses and of its very striking 'homing' activities. Some account is also given of the intimate physiology of the repugnatorial glands of this species.

39. *The Olfactory Sense of Orthoptera.* N. E. McINDOO, Bureau of Entomology, Washington, D. C.

Last year, before this society, I presented an abstract concerning the morphology of the olfactory pores of Orthoptera. Since then I have performed experiments on grasshoppers and crickets to determine whether or not their antennae serve as olfactory receptors. The intact insects were first tested to ascertain their reaction times to the oils of peppermint, thyme, wintergreen, and lemon, and to the dried leaves of pennyroyal and to bran mash (their food in captivity). Each antenna was then severed through the third segment, and twenty-four hours later these mutilated insects were again tested with the above sources of odors. The average reaction time of the intact grasshoppers is 8.4 seconds, and of them after being mutilated, 9 seconds. The average reaction time of the intact crickets is 8.8 seconds, and of the same crickets after being mutilated, 10.2 seconds.

The longevity of these mutilated insects was the same as that of other intact ones. Since the antennae were cut off just distal to the olfactory pores on the first and second segments, it seems that the remainder of the antennal segments do not bear the olfactory organs as other investigators claim.

40. *On a new principle underlying movement in organisms.* A. A. SCHAEFFER, University of Tennessee.

Organisms possessing orienting senses react with reference to the environment when these senses are strongly stimulated. Organisms lacking orienting senses or in which the orienting senses are made ineffective in one way or another move in characteristic paths when freely moving. So far as observation goes, all motile plants and all animals, when not guided by orienting senses are influenced, while freely moving, by some agency so that the resulting path resembles some form of spiral. The tendency of organisms to move in definite spiral paths is of measurable strength, for slight obstructions in the path fail to cause a change in the direction of movement, and some organisms with rather poorly developed sense organs nevertheless move in spiral paths regardless of the presumed receipt of sense impressions by the orienting sense organs. The fundamental path followed by moving organisms is therefore a spiral, and it is only through the agency of orienting senses that organisms are able to change their direction of movement. The great diversity of form observed in organisms that move in spiral paths indicates that the automatic mechanism regulating the direction of the path is not dependent upon or connected with morphological structures, but is much more fundamental in its nature, affecting the protoplasm directly. This study is based upon observation of the movements of bacteria, oscillatoria, gametes and zoospores of algae, zoospores of fungi, ameba, ciliates, flagellates, flatworms, nematodes, rotifers, oligochaetes, larvae of molluscs, larvae of echinoderms, larvae and adults of copepods, larvae of aquatic insects, man.

41. *The relation of the concentration of oxygen to the rate of respiratory metabolism in Planaria.* E. J. LUND, Laboratory of General Physiology, University of Minnesota.

The rate of oxygen consumption by *Planaria* begins to diminish at concentrations of oxygen in water equal to one-third to one-fourth that of air saturation at 20°C. The animals were unable, under conditions of the experiments to adjust themselves to the low concentrations of oxygen by increasing the rate of oxygen consumption at low concentrations. After living in very low concentrations of oxygen for periods of one to twenty-four hours, the rate of oxygen consumption when returned to air-saturated water is temporarily increased to a greater or less extent. This increase is probably due to temporary increased motor activity. Very high concentrations do not appreciably affect the rate of oxygen consumption. The rate of carbon dioxide production in hydrogen for periods of from one to twenty hours remains practically

the same as that in air-saturated water. Loss of irritability in hydrogen is correlated more directly to a decrease in carbon dioxide production than to an absence of consumption of free oxygen. Absence of oxygen and solutions of potassium cyanide affect the respiratory metabolism of *Planaria* in different ways, contrary to what one would be led to think from statements in the literature on the question.

42. *Experimental studies on the cerebral cortex and corpus striatum of the pigeon.* F. T. ROGERS, Marquette School of Medicine.

In the pigeon the cerebral cortex is feebly developed and the boundary between it and the so-called corpus striatum is ill-defined. In previous papers an attempt has been made to definitely assign certain physiological activities with the corpus striatum and the thalamus. The present work is an attempt to make a further statement of the physiological activities of the striatum and this simple type of cortex.

Cauterization and removal with the knife of the superficial cortical portion of the hemispheres to a depth of about one-eighth of an inch (with the exception of the extreme medial and posterior parts) leaves an animal which, as the early workers stated, is 'deficient in intelligence.' Such a bird, after a period for recovery from the trauma of the operation, exhibits the following types of instinctive behavior; feeding, bathing, fighting, the entire cycle of mating reactions, including incubation of eggs and feeding and rearing a brood. If the striate bodies are removed in toto all these reactions disappear.

The decorticated male differs from the normal bird in the following respects: 1) Greater tendency to a fixed type of reaction. Thus the male will give the courting and fighting reaction to any small moving object, but only while it is moving. There is no spontaneous fighting of an object or bird which is not moving. 2) Absence of fear reactions and of efforts to escape from confinement. No spontaneous flight of escape when the bird is unconfined by a cage. 3) Avoiding reactions of flight can be induced by mistreatment of the bird (strong stimulation), but not by moving objects which do not touch the bird. 4) Reactions are more readily fatigued than in the normal bird.

These observations apply to birds kept for three to six months after operation.

Physiologically, the cortical part of the hemispheres is related to the production of a greater variety of reactions from a single stimulus; to the lowering of the threshold for distant stimuli; to the exertion of an augmentor effect so that the reactions are more prolonged and persistent.

As long ago recognized by Flourens, the reaction deficiencies of birds in which different amounts of the fore-brain are removed are proportional to the quantity of tissue destroyed and not to the loss of particular centers. In other words, so far as the pigeon is concerned, no motor or sensory localization in the cortex has been proved. The want of such special centers, together with the persistence of instinctive reactions after its removal, and the deficiencies in adaptation mentioned

above, lead to the suggestion that such cortex as is present is a primitive form which, intimately related to the striatum, may be a type of tissue intermediate between it and the true cortex of higher forms.

43. *Photic orientation in the drone-fly, Eristalis tenax.* S. O. MAST, The Johns Hopkins University.

It has been maintained that photic orientation in insects depends upon the relation in the tonus of the muscles of the legs on opposite sides of the body and that this relation in tonus depends upon the relation in the amount of light received by the two eyes; that is, if the light is unequal, the tonus of the muscles on opposite sides differs, resulting in differences in the rate of locomotion on the two sides and turning until the two eyes are equally illuminated and the organism is oriented. The following results indicate that the process of orientation may be much more complicated than this:

1. If the two front legs on one side are removed, orientation is nearly as precise as it is in normal specimens, showing that orientation is not necessarily dependent upon the relation in tonus in the muscles of the legs on opposite sides.

2. If one eye is covered orientation may still occur. This shows that it is not necessarily dependent upon the relation in amount of light received by the two eyes.

3. If the two front legs on one side are removed and either eye is covered, proper unilateral illumination may still induce turning either to the right or the left, showing that the movements of the legs may be controlled by impulses received from either eye.

4. If the two front legs on one side are removed and the eye on the opposite side is covered, illumination of the posteriolateral surface of the functional eye induces backward movement of the legs on the normal side; illumination of the lateral surface, lateral movements; illumination of the anteriolateral surface, forward movement, and illumination of the anteriomedian surface, forward movement toward the median line. This shows that the response depends in part upon the location of the stimulus in the eye, and not solely upon the magnitude of the stimulus.

44. *Behavior of a tunicate larva.* W. J. CROZIER, The University of Chicago.

The large larva of the Bermudan Ecteinascidia was employed for an analysis of the habits of this tunicate in its free-swimming stage. It was sought to obtain data for study of the relations between the movements of the larva at different ages and the corresponding central nervous changes during metamorphosis. The first communication will deal with the modifications of photic responses during the larval period and with the concomitant changes in the eye. A relatively long larval existence (twenty-four to forty-eight hours), combined with large size (>4 mm.) and an abundant supply of material, provided very favorable conditions.

45. *Vision in the seventeen-year locust, Cicada septendecim.* S. O. MAST,
The Johns Hopkins University.

Immediately after the pupae of the seventeen-year locust emerge from the ground they go directly toward some object, usually a tree, which they ascend. The imagoes when placed on the ground behave just like the pupae in reference to objects about them. They clearly select trees in preference to posts, stumps, boards, buildings, etc. They almost never climb up on buildings unless they are covered with vines. Light which is reflected from the trees undoubtedly guides these creatures, for if it is dark or if their eyes are covered they no longer go toward the trees. While the trunks of most trees are considerably darker than the remaining background, those of some trees, e.g., the sycamore, are lighter. The locusts, however, go toward the latter as well as toward the former. Hence, their positive reactions to trees is largely independent of the intensity of the light received from them. It is not primarily the amount of light that comes from the trees in contrast with the amount that comes from other regions in the background that guides them. It is probably the configuration, the outline of the objects as determined by differences in illumination. And if this is true, the Cicada have the power of vision as objectively determined.

How the eyes and vision originated in these animals in which they are functional only a few weeks during the seventeen years of their life is an interesting problem.

46. *Periodicity in photic responses in the euglenoid, Septocinclis texta, and its bearing on reversion in the sense of orientation.* S. O. MAST,
The Johns Hopkins University.

Changes in various physiological processes occur periodically in many different organisms in harmony with periodic changes in the environment, e.g., light and darkness. In some organisms these changes continue to occur for some time with the same periodicity in the absence of changes in the environment to which they were formerly related, e.g., the sleep movements in plants, and reactions in harmony with the ebb and flow of the tide in *Convolvula*. In the unicellular forms no such reactions have heretofore been discovered.

Septocinclis texta, like many of the other euglenoids, responds very definitely to light. It may be positive or negative. If it is kept continuously in total darkness and tested from time to time in a given illumination of proper intensity, it is found to be positive from early in the morning up to about 1 p.m. Then it becomes negative and remains so until 8 or 9 p.m., when it becomes positive again and remains so until the following afternoon. Thus in the absence of light there appears to be in its physiological processes a periodicity which is normally associated with alternation between day and night, and determines the sense of its orientation to light. This periodicity continues in the total absence of light for at least three days.

47. *Adaptation to light in Euglena variabilis* (?) and its bearing on reversion in orientation. S. O. MAST, The Johns Hopkins University.

It is well known that *Euglena* is positive in its reactions to light under certain conditions and negative under others, and it is fairly generally assumed that the reversion from positive to negative and vice versa functions in a tendency to attain optimum illumination, that strong illumination induces negative and weak illumination positive orientation.

In carefully controlled experiments it was found that *Euglena variabilis* rapidly becomes adapted to any given illumination, that its reaction to light of any given intensity depends upon the intensity of the illumination to which it is adapted. In general, if it is adapted to low illumination or darkness, it is negative in strong and positive in weak light and it tends to aggregate in moderate illumination. But if it is adapted to high illumination, the reverse holds, it is positive in strong and negative in weak light and it tends to aggregate in very high and in very low illumination. Thus the sense of orientation in specimens adapted to strong light is just the reverse of that of those adapted to weak light. It is not known whether low and high illumination is optimum for specimens adapted to light of high intensity; nor is it known whether moderate illumination is optimum for those adapted to that of low intensity, although it is frequently assumed to be.

48. *The maze-behavior of white rats in the second generation after alcoholic treatment.* E. C. MACDOWELL AND E. M. VICARI, Carnegie Institution of Washington.

The behavior in the Watson maze of 23 rats (tests) from alcoholized grandparents has been compared with that of 23 genetically comparable control rats (controls) from normal grandparents. Each rat was given three trials a day for eight days; after a vacation of thirty days, 12 trials more were given (four days) as a test of retention. By the averages based on the total time spent by a rat on the three trials in a day, the test rats were shown to be slower than the controls. The ratios of the averages per day of the controls to the tests favor the controls on 10 of the 12 days; their average departure from equality is 0.46 of the tests' time per day; the departures from equality range from 0.23 to 0.81. The ratios on the two days that the averages of the tests were faster than those of the controls depart from equality by 0.060 and 0.005. The inferiority of the tests is borne out by summarizing the time data in various ways, as well as by other series of data involving 'errors' and 'perfect trials' taken from the same reactions.

49. *The relation of modifiability of behavior and metabolism in land isopods.* C. H. ABBOTT, Massachusetts Agricultural College. (From the Osborn Zoological Laboratory, Yale University; introduced by Henry Laurens.)

The experiments were devised to determine whether photonegativity in land isopods is dependent on the maintenance of normal metab-

olism and whether alterations in the latter caused by environmental agencies can alter the former.

Tests were made of the effects, 1) of dry atmosphere at various intervals up to a point of desiccation; 2) of heating to a series of temperatures from 20° to 40°C.; 3) of refrigerator temperatures; 4) of preceding exposure to high illumination.

It was found that excessive dryness and a gradual rise in temperature above the optimum were accompanied in many instances by a modification or reversal of the reaction to light. This occurred in three species belonging to two genera. No modification followed exposure to low temperature or exposure to strong light.

The conditions under which modification occurred were those in which metabolism of a destructive nature was caused, while those in which no modification took place were states either of lowered bodily activity or of unaltered general metabolism. This indicates a correlation between the negative reaction and optimum environmental conditions. Either is important for the maintenance of the other.

50. *The rate of carbon dioxide production by pieces of Planaria in relation to the theory of metabolic gradients.* GEORGE DELWIN ALLEN, University of Minnesota (introduced by E. J. Lund).

The rate of carbon dioxide production by pieces of *Planaria agilis* was measured for the purpose of testing the well-known theory of axial gradients in rate of metabolism. The method described by Lund was employed. Pieces of the same size from the same body region of forty to seventy-five worms were placed together for a single determination. Pieces representing different body regions were taken from the same specimens. Every experiment included three sets of pieces of each kind and comparisons are made between pieces tested simultaneously under identical conditions. Each set of worms was weighed and the carbon dioxide production per gram body weight per twenty-four hours was calculated. Repeated determinations extending over two to five days following the cutting operation were made upon the same pieces.

Such differences as were observed between the rate of carbon dioxide production by pieces were very small, did not form a regularly graded series in the order demanded by the theory of metabolic gradients, and were associated with other factors than the positions of the pieces in the original body axis. Smaller pieces showed a slightly higher rate than larger pieces from the same or different regions, and pieces which included a portion of the pharynx region had a slightly higher rate than pieces of the same size from the region entirely anterior to the pharynx.

The rate of carbon dioxide production by pieces was higher than that by headless worms or than that by normal worms. When constant temperature was maintained this increased rate was permanent, within the limits of the experiment, and could not be attributed only to a temporary stimulation by the cutting operation.

These observations do not support the theory of metabolic gradients, which was based originally upon data concerning the course of disintegration of *Planaria* in potassium cyanide solutions and the speed and character of regeneration in different regions of the worm. Quantitative measurements of the rate of carbon dioxide production by successive pieces cut from the body of *Planaria* do not show graded differences such as are supposed by the theory to characterize their respective regions in the whole worm.

EVOLUTION

51. *Irreversible differentiation and orthogenesis.* C. JUDSON HERRICK, University of Chicago.

The widely current belief that variations sometimes occur in progressive series set in a definite direction rather than always in accordance with the probability curve of chance deviations around fixed unit characters has been strongly supported by the posthumous publication of Whitman's works. But the mechanism of such orthogenetic movements remains obscure. The progressive senescence of tissue in both ontogenetic and phylogenetic series involves a stabilization of originally undifferentiated plastic tissue into fixed structural patterns (Child). So far as this differentiation is heritable and irreversible, the future course of evolution is thereby intrinsically determined, for variations will be distributed around the new pattern as a mode in accordance with a different frequency curve than would be shown if the inherited structural pattern were different. The process of differentiation is therefore itself a natural cause of limitation of the future course of evolution within boundaries set by the efficient working of the established pattern. The nervous systems of arthropods, teleosts, reptiles, and mammals furnish illustrations of the effect of such irreversible differentiation on the course of animal evolution.

52. *An analysis of the sexual modifications of an appendage in sex-intergrade Daphnia longispina.* A. M. BANTA and MARY GOVER, Station for Experimental Evolution.

A detailed analysis of one of the appendages, the first leg, which is subject to wide modification in secondary sex characteristics, in sex-intergrade strains of *Daphnia longispina* brings out the following facts:

1. Every detail of this appendage which is subject to sexual modification is also subject to intermediate development in sex-intergrade individuals.

2. The intermediate development of any portion of this appendage may represent any condition from a just distinguishable modification from that characteristic of the normal female to a condition approaching the normal male condition.

3. The different portions of the same individual appendage may show a range from fully female to moderately male in character, or from an intermediate condition to a fully male condition.

4. There is usually, however, a certain amount of correlation between the amount of maleness and femaleness manifest in the different portions of the same appendage, although this correlation is not sufficient to enable one to make a safe prediction from the amount of maleness manifest in one portion as to the condition of the other sexually modified portions of the same individual appendage.

COMPARATIVE ANATOMY

53. *The urodelevomer.* INEZ WHIPPLE WILDER, Department of Zoology, Smith College.

The report here given is based on a study of the following representatives of three quite distinct families: *Spelerpes bislineatus*, *Diemictylus viridescens*, and *Ambystoma punctatum*. In all of these the close similarity of the larval skull to the skull of *Necturus* is particularly marked in the case of the bones located in the roof of the mouth. The deficient anterior arcade of teeth presented by the premaxillaries alone, and the more extensive posterior arcade formed by the two vomers supplemented at their lateral extremities by the toothed anterior regions of the palatopterygoids show a condition almost identical with that in *Necturus*. The choanae are slit-like apertures lateral to the posterior ends of the vomers.

During metamorphosis maxillaries make their appearance, and there is a disintegration, beginning in the anterior region of the palatopterygoid and continuing, in the case of *Spelerpes*, until the palatopterygoid has entirely disappeared, while in the other two forms the posterior portion remains as the pterygoid of the adult. Simultaneously there is a profound metamorphosis of the vomer, the following details of which have been worked out in *Spelerpes*: 1) an anterior and lateral extension of the bone as a platelike reinforcement of the floor of the metamorphosing nasal region, the plate eventually joining the maxillary laterally, and almost encircling the choana with its latero-posterior border: 2) an extension of the medial border, mainly in a posterior direction, through the fusion of the bases of a new series of teeth which appear at this time in the roof of the mouth in a longitudinal row on either side of the midline, eventually forming a much elongated, attenuated, toothed process, and, 3) the absorption of the larval vomerine teeth and of the ridges which bore them, so that this region becomes thin and plate-like like the adjoining newly developed regions. The metamorphosed *Diemictylus* vomer is almost identical in appearance with that of *Spelerpes*, but in *Ambystoma* no longitudinal rows of teeth appear in the roof of the mouth, and the metamorphosed vomer lacks, therefore, the elongated toothed process.

In *Spelerpes*, after metamorphosis, the posterior region of the toothed process grows wider by the fusion of more teeth, and it eventually becomes detached from the vomer, thus forming the 'parasphenoid tooth patch' characteristic of the *Plethodontidae*; in *Diemictylus* the toothed process persists as a characteristic part of the adult vomer.

54. *The origin, function and fate of the test-vesicles of Amaroucium constellatum.* (With lantern.) CASWELL GRAVE, Washington University.

In the fully developed tadpole larva of *A. constellatum* approximately sixty spherical, multicellular vesicles occupy a considerable part of the space of the anterior median region of the tunic. The vesicles take their origin as elongated evaginations from four median sagittal elevations of the ectodermal layer of the immature tadpole, but, at a later stage, each constricts near the point of its attachment, then becomes free and migrates through the substance of the comparatively thick larval tunic to a point midway between the body and the external surface of the tunic where it remains throughout the free swimming period of the tadpole, in form and structure each vesicle is strikingly similar to an echinoderm blastula. Its epithelial wall, which is thickened on the side turned toward the external surface of the tunic, is composed of approximately one hundred cells. When the tadpole begins its metamorphosis, the vesicles immediately migrate to the external surface of the tunic and begin to proliferate cells into the tunic substance. New test material rapidly appears in the regions occupied by the vesicles, secreted by the cells of the vesicles proper and by the cells proliferated by them. During the first several hours after the inception of metamorphosis, the vesicles all are located about the attached end of the developing ascidiozoid, but, by the end of twenty-four hours, they have taken on an approximately equal distribution over the entire external surface of the tunic. A colony of rapidly increasing size and number of ascidiozooids is formed within a common tunic by the asexual multiplication of the primary and secondary ascidiozooids. It is with the formation and regulation of the common tunic of the colony that the test vesicles are concerned. Throughout the life of the colony they continue to occupy positions at the external surface and to proliferate cells, some of which take their places at and in the surface epithelium of the tunic, while others are distributed within the tunic substance. No increase or decrease in the original number of vesicles takes place during the life of the colony. No structural connection between the vesicles and the ascidiozooids has been made out. The vesicles are derived from the individual by which the colony is founded but they continue to exist and function many generations after the primary zooid has lost its identity. They are organs of the colony as a whole.

55. *Respiratory organs of Ucides caudatus, a West Indian land crab.* (Illustrated with lantern slides.) C. C. NUTTING, University of Iowa.

Ucides caudatus, or hairy-legged land crab, was found at Antigua living in a mangrove swamp, where it was partly aquatic and partly terrestrial in habit. The branchial chamber is divided into an upper (pulmonary) and a lower (branchial) portion, the two separated by a shelf attached to the branchiostigite. There are three brush-like flagella attached to the maxillipeds and serving to moisten the edges of the gills.

The upper, or pulmonary, chamber is lined by a rubber-like and highly vascular membrane ending in what appear to be respiratory villi for aerial respiration.

On the body wall proper, projecting into the pulmonary chamber are two structures which the writer cannot explain: a) a large, turgid, S-shaped body, which may be an enormous blood sinus conveying the blood to the pulmonary chamber; b) a number of stiff, slender, capitate rods, borne on the thin body wall and projecting rigidly into the pulmonary chamber.

The respiratory apparatus seems to be midway between that of a *Gecarcinus* reported on by the writer in 1895 and that of *Birgus latro*, an almost completely terrestrial form from the East Indies.

(To be published in Studies in Natural History, State University of Iowa.)

56. *The homologies and development of the palpal organ of male spiders.*

W. M. BARROWS, Ohio State University.

The palpal organ of male spiders is a hypertrophied claw homologous with the smaller claw on the female palp. This claw is homologous with the dactylus of scorpions, pseudoscorpions, and crustacea, and is moved by similar flexor and extensor muscles. Before the last molt of the male spider, the gland which secretes the claw is pulled back toward the center of the tarsus by the attached muscles which then degenerate. The mass of gland cells which now forms the fundament of the palpal organ develops an inner tube by the invagination of cells from the tip. In its cramped position the claw twists around on itself, developing at the same time variously shaped teeth which usually correspond with unmodified teeth on the female claw. The muscles operating the claw or palpal organ appear to degenerate and to be replaced by a new set of muscles after each molt.

57. *Morphology of the enteron of the periodical cicada (Tibicen septendecim Linn.).* CHAS. W. HARGITT and L. M. HICKERNELL, Syracuse University.

The present account deals only with the morphology of the digestive system of the adult insect. Work on the various nymphal stages will be published shortly.

There is a well-differentiated and continuous digestive tube in both the male and female insects. The earlier statements as to the discontinuity and apparent atrophy of the tube are not confirmed. It is true that there is a progressive enlargement of the middle portion of the tube accompanied by a thinning of the digestive epithelium as adult life proceeds, but there is no degeneration in the sense that any part ceases to be well organized or that the parts become disconnected from each other.

The pharynx is followed by the esophagus which is relatively short and has a small lumen. At the posterior extremity of the esophagus is a valve which marks the beginning of the crop. In the crop region

two structures are to be distinguished—the crop proper and the coil of tubes made up of intestine and malpighian vessels just dorsal to the crop. Following the crop is an enlarged portion, at the posterior end of which the intestine begins. The latter runs in a general anterior direction until it reaches the crop region and with the malpighian vessels forms the labyrinth mentioned above. After emerging from this coil the tube turns abruptly toward the posterior end and, proceeding dorsally, runs as far as the seventh abdominal segment where it empties into the rectum.

58. *Sexual dimorphism in nemerteans.* W. R. COE, Yale University.

Several species of pelagic nemerteans belonging to the genus *Nectonemertes* (Verrill) are characterized by the possession of a pair of lateral muscular appendages situated immediately back of the head. Recent studies have shown that these organs (tentacles) occur only in the male sex and that they become fully developed only with the sexual maturity of the animal, as Bergendal has already suggested. The genital glands of the males are limited to the head region, while those of the female are distributed between the intestinal diverticula throughout the length of the body. The spermaries are provided with a powerful musculature for the forcible ejection of the mature sperm cells. There is thus a striking dissimilarity between the sexes. The two individuals are so different, in fact, that the females have been hitherto placed in a separate genus, *Hyalonemertes* (Verrill).

The tentacles are highly muscular and may reach a length considerably greater than the breadth of the body. Their function is presumably both of a tactile and prehensile nature. In several species of the genus the males have been caught on nets or fishing lines to which they were clinging with their tentacles, while the females are as yet undescribed. The principal service of the tentacles is presumably to hold the two individuals together during the process of insemination. The possession of such organs is of obvious advantage to a species the individuals of which are widely scattered over hundred of square miles of the open ocean and have a range in depth of several hundred fathoms.

59. *The columella auris of the Reptilia.* EDWARD L. RICE, Ohio Wesleyan University.

The reptilian columella auris has been interpreted, *a*) as of otic origin; *b*) as of hyoid origin, and *c*) as a dual structure, the otostapes arising from the otic capsule and the hyostapes from the hyoid arch. A study of six embryonic stages of the lizard *Eumeces* indicates a genetic relation of the proximal portion of the columella to the otic capsule and of the distal portion to the hyoid arch; it also indicates that the entire columella is a unit structure. This seeming contradiction is tentatively explained on the assumption (applied by Gaupp and others to other regions of the skull) that the embryonic connective tissue of the head has a general potentiality of cartilage formation, called into local actuality by developmental stimuli. Thus the columella is not devel-

oped from the otic capsule nor from the hyoid arch; rather all three are developed from a continuous embryonic stroma and later differentiated into separate skeletal elements. This interpretation may help to harmonize the conflict of opinion on the columella.

60. *The spiracular sense organ of elasmobranch, ganoid, and dipnoan fishes.* H. W. NORRIS and SALLY P. HUGHES, Grinnell College.

Various diverticula of the spiracle of the elasmobranchs have been described, in one of which a sense organ has been found (Wright, '85; van Bemmelen, '86; Allis, '01). Among the ganoids *Amia* and *Lepidosteus* have similar spiracular sense organs (Wright, '85; Allis, '97). Pinkus ('95) found in *Protopterus* a vesicular sense organ in the spiracular region. Agar later ('06) demonstrated the origin of the organ from the spiracle in both *Protopterus* and *Lepidosiren*. In all these instances the innervation of the sense organ is from the ramus oticus facialis, or from a small branch arising from the main nerve near the base of the ramus oticus. In *Squalus acanthias* the writers find the spiracular organ of variable structure, in its fully developed form a tubular organ consisting of a vestibule with three diverticula, in each of the latter a sensory ending. From its structure and innervation, and from the fact that Brohmer ('08) finds in the embryo of *Spinax* a group of ampullae of Lorenzini in the spiracle, the writers conclude that the spiracular sense organ of fishes is a modified ampulla of Lorenzini.

INVITATION PROGRAM

61. *Faunal areas on the Pacific slope of South America.* C. H. EIGENMANN, University of Indiana.

I. *Nature of the Area.*

The territory of South America draining into the Pacific between Panama and Puerto Montt is about three thousand miles long and usually less, rarely over, one hundred miles wide. Between Central Colombia and South Central Chile its eastern boundary is everywhere over six thousand feet elevation, and usually far above. This elevation presents an effective barrier against the migration from the east of all but the fishes acclimated to the highest altitudes.

The climatic conditions in different parts of this long stretch are very different. Ventura, lying in the tropics, in the north, and Puerto Montt in the south temperate zone, have a rainfall of over a hundred inches per annum. Over half of the entire stretch—the area between Paita and Copiapo—is without any rain except in high altitudes. Numerous rivers rise in the high Andes and after a short, turbulent course toward the west, empty into the Pacific. Only the San Juan, Guayas, Santa and Loa have any north or south trend.

II. *The Nature and Origin of the Faunas of the Pacific Slope in Gross.*

The strip is readily divisible into two. The part in Peru and northward contains one fauna, the Pacific slope of Chile has an entirely

different fauna. Only *Pygidium*, and in the southern part *Basilichthys*, are common to the two regions. Where the dividing line may be has not been definitely determined. In the Rio Copiapo, the first river south of the Desert of Atacama, in south latitude 27°, I found no native fishes. Going south from Copiapo first one then another species is added till the full complement of the Chilean fauna is reached about Santiago and Valparaiso. There is greater difference between the faunas of Chile and Ecuador-Colombia than between the faunas of southern Texas and Colombia. There are two distinct, though overlapping faunas in Chile. One flourishes north of Concepcion and is autochthonous. This fauna diminishes from Santiago northward till it reaches the vanishing point of Copiapo.

At Concepcion Australian types begin to appear and at Valdivia they are in full force although the northern types persist at least to Puerto Montt. This southern fauna has had an origin in common with that of New Zealand and Australia. The fauna of the Pacific slope of Peru, Ecuador and Colombia is distinctly tropical American in type. This fauna diminishes southward through the dry regions of Peru, reaching the vanishing point in southern Peru. North of the Guayas conditions remain about the same to Panama. The northern part of this fauna was derived from the Magdalena basin and the Magdalena fauna, in its essence, antedates the Cordilleras, separating it from the Orinoco and Amazon basins.

III. The Faunas of the High Altitudes.

Associated with the Pacific slope fishes is the nature of the fauna of the high altitudes.

Three genera are of interest here.

1. *Pygidium*. This is preëminently a fish of swift waters or high altitudes, or both. It is found in all the streams, in any way favorable, between Panama and Puerto Montt, and from an elevation of at least 12,000 feet to sea level. All the faunas of the Pacific slope from southern Panama to Puerto Montt are tinctured with members of this genus. It is found on both slopes. On the Pacific slope it descends the rivers to the coast; on the Atlantic it reaches in places to the ocean. The numerous species are concomitant products of the formation of the territory they now occupy.

2. The genus *Orestias*, of several species, is confined to the stagnant parts of the rivers from 7000 feet to over 15,000 feet from Cerro de Pasco to northern Chile. Very few of its species are found in the lakes draining into the upper courses of Pacific slope streams. It is preëminently a genus of the Titicaca basin and of other elevated lakes. It belong to the *Pœciliidae*, a family of lowland fishes and went up with the territory it now occupies.

3. The genus *Astrobblepus*, with about 30 species, is found on both slopes in rapid streams as high as 12,000 feet, descending the streams in favorable places to near sea level (300 feet). It is found from just north of the Titicaca basin to Panama and Merida and is a derivative of the universally distributed *Loricariidæ* in the territory it now occupies.

62. *Polyembryony and sex.* J. T. PATTERSON, University of Texas.

In studying the development of polyembryonic hymenoptera, two species have been found which show a large percentage of mixed broods. The egg of one of these, *Paracopidosomopsis floridanus* Ashmead, produces several asexual larvae in addition to the sexual individuals. The origin of these curious larvae can be traced to a very early stage of development. In the second species, *Platygaster felti* Fouts, practically all of the broods are mixed, and in the majority of cases a single male is present in each brood. The suggestion is made that the appearance of mixed broods and asexual larvae can be explained on the assumption that one or two sex chromosomes have been eliminated from some of the blastomeres during the cleavage stages.

63. *Physiological life-histories of terrestrial animals.* V. E. SHELFORD, Illinois Natural History Survey and the University of Illinois.

The conditions of existence and responses of terrestrial animals to climatic factors have not received their proper share of attention, due to the difficulties of simulating climatic and weather conditions. Extended studies of three species of insects (including the codling moth) have been carried on in special apparatus in which account was taken of temperature, humidity, air movement, evaporation, light, and variability of conditions. The physiological zero or threshold of development for temperature differs with humidity, with different generations, and with amount of variability. The length of stages, value of Q_{10} , etc., differ with humidity, light, air movement, and variability. In one species at optimum temperatures, a difference of 30 per cent in humidity doubles the length of instars; in the other two the difference with fall of 30 per cent from the optimum causes differences of 1 to 15 per cent in the length of instars. Under optimum conditions of temperature and humidity, increase of air velocity which increases evaporation by three to six times, shortens pupal life of the codling moth by 10 per cent or more. Variability of temperature (4°C.) stimulates metabolism and shortens pupal life in the codling moth from 1 to 10 per cent. Light stimulates development in the codling moth and probably the other two species. The number of generations is within limits, under the control of weather; hibernation occurs, but may be broken up by controlling water content of the insects with no lowered temperatures whatever. The results are of such a character as to make possible predictions as to the time of appearance of the insects concerned. They confirm various observations on man and have important bearings on several aspects of science.

64. *The work of the National Research Council in relation to Zoology.*

C. E. McCLUNG, Chairman Division of Biology and Agriculture, National Research Council.

No abstract received.

AMERICAN SOCIETY OF ZOÖLOGISTS

CONSTITUTION, OFFICERS AND LIST OF MEMBERS OF THE SOCIETY

CONSTITUTION

ARTICLE I

NAME AND OBJECT

Section 1. The Society shall be called the "American Society of Zoölogists."

Sec. 2. The object of the Society shall be the association of workers in the field of Zoölogy for the presentation and discussion of new or important facts and problems in that science and for the adoption of such measures as shall tend to the advancement of zoölogical investigation in this country.

ARTICLE II

MEMBERSHIP

Section 1. Members of the Society shall be elected from persons who are active workers in the field of Zoölogy and who have contributed to the advancement of that science.

Sec. 2. Election to membership in the Society shall be upon recommendation of the Executive Committee.

Sec. 3. Each member shall pay to the Treasurer an annual assessment as determined by the Society. This assessment shall be considered due at the annual meeting and the name of any member two years in arrears for annual assessments shall be erased from the list of members of the Society, and no such person shall be restored to membership unless his arrearages shall have been paid or he shall have been re-elected.

ARTICLE III

OFFICERS

Section 1. The officers of the Society shall be a President, a Vice-President a Secretary-Treasurer and the members at large of the Executive Committee

Sec. 2. The Executive Committee shall consist of the President, the Vice President, the Secretary-Treasurer and five members elected from the Society at large. Of these five members, one shall be elected each year to serve five years. If any member at large shall be elected to any other office, a member at large shall be elected at once to serve out the remainder of his term.

Sec. 3. These officers shall be elected by ballot at the annual meeting of the Society and their official terms shall commence with the close of the annual meeting, except that the Secretary-Treasurer shall be elected triennially and shall serve for three years.

Sec. 4. The officers named in Section 1 shall discharge the duties usually assigned to their respective offices.

Sec. 5. Vacancies in the board of officers, occurring from any cause, may be filled by election by ballot at any meeting of the Society. A vacancy in the Secretary-Treasuryship occurring in the interval of the meetings of the Society may be filled by appointment, until the next annual meeting, by the Executive Committee.

Sec. 6. At the annual meeting the President shall name a nominating committee of three members. This committee shall make its nominations to the Secretary not less than one month before the next annual meeting. It shall be the duty of the Secretary to mail the list of nominations to all members of the Society at least two weeks before the annual meeting. Additional nominations for any office may be made in writing to the Secretary by any five members at any time previous to balloting.

ARTICLE IV

MEETINGS OF THE SOCIETY

Section 1. Unless previously determined by the Society the time and place of the annual meeting of the Society shall be determined by its Executive Committee. Special meetings may be called and arranged for by the Executive Committee. Notices of such meetings shall be mailed to all members of the Society at least two weeks before the date set for the meeting.

Sec. 2. Sections of the Society may be organized in any locality by not less than ten members, for the purpose of holding meetings for the presentation of scientific papers. Such sections shall have the right to elect their own officers and also associate members; provided, however, that associate membership in any section shall not confer membership in the Society.

ARTICLE V

QUORUM

Twenty-five members shall constitute a quorum of the Society and four a quorum of its Executive Committee.

ARTICLE VI

CHANGES IN THE CONSTITUTION

Amendments to this Constitution may be adopted at any meeting of the Society by a two-thirds vote of the members present, upon the following conditions:

(a) The proposed amendment must be in writing and signed by at least five members of the Society.

(b) This signed proposal must be in the hands of the Secretary at least one month before the meeting of the Society at which it is to be considered.

(c) The Secretary shall mail copies of the proposed amendment to the members of the Society at least two weeks before the meeting.

BY-LAWS

DUES

(1) The annual dues for members, unless remitted or changed by the vote of the Society, shall be seven dollars.

SECRETARY-TREASURER

(2) The duties and privileges of the Secretary-Treasurer shall be as follows:

(a) He shall keep the records and be in charge of the funds of the Society.

(b) At the annual business meeting he shall present a statement to date of the funds of the Society.

(c) Whenever the proper officers of a number of related societies shall have a conference with a view to determining a common time and place for the several annual meetings, he shall act as the delegate or representative of this Society. (See also 4-a.)

(d) He shall employ a typewriter or printer whenever in his judgment such employment will expedite the business of the Society, and

(e) He shall be reimbursed out of the funds of the Society for expenses incurred in attending meetings of the Society.

AUDITING COMMITTEE

(3) The President shall annually appoint an auditing committee of two, who shall audit and report upon the financial record and statement of the Secretary-Treasurer at the meeting for which they were appointed.

(4) The National Research Council allows the Society three representatives on the Division of Biology and Agriculture. Of these three representatives, one shall be elected each year to serve three years. The method of election shall be the same as that used in the election of the officers of the Society.

AFFILIATION WITH THE AMERICAN SOCIETY OF NATURALISTS

(5) Affiliation with the American Society of Naturalists is provided for as follows:

(a) It shall be the policy of the Society to hold its annual meetings in conjunction with the American Society of Naturalists, whenever satisfactory arrangements to do so can be made; and, with this in view, before the time and place for an annual meeting shall have been determined by the Executive Committee, the Secretary-Treasurer shall ascertain from the Secretary of the American Society of Naturalists the time and place for holding the annual meeting of that Society. It shall be the policy of the Society, however, to hold meetings in both Eastern and Central-Western territory, and the distribution of the meetings between the two territories shall be determined in general on the basis of the representation of Eastern and Western members in the Society. See also 2-c.

(b) When the annual meeting is held in conjunction with the American Society of Naturalists, the Society shall adjourn for one session (morning or afternoon) to meet in joint session with the American Society of Naturalists, and it shall be the policy of the Society to conclude its annual meeting with the Naturalists' dinner and the Secretary-Treasurer is instructed to urge upon the Naturalists the propriety of adjusting their program with this point in view

PROGRAM RULES

(6) In matters relating to programs for annual meetings the following rules shall be observed:

(a) Papers shall be listed and presented according to subject matter in the following groups: 1. Comparative Anatomy; 2. Embryology; 3. Cytology; 4. Genetics; 5. Comparative and General Physiology; 6. Ecology, and 7. Miscellaneous, or other groups at the discretion of the Secretary-Treasurer.

(b) Whenever conditions require it the Executive Committee shall schedule two or more groups for the same hour and rearrange the program to bring together papers on subjects of more general interest for meetings of the whole Society. The Committee, however, is instructed to avoid conflicts as much as possible.

(c) Papers shall be listed in their respective groups in the order received. When a member offers more than one paper those following the one designated first shall be placed at the end of the list and shall not be read until all first papers by members shall have been twice called for.

(d) All papers not read when called for as listed shall be placed at the end of the group list, and, if not read when called for the second time, they shall be read by title only.

(e) The titles of "introduced" papers shall be listed in the groups after the titles of papers to be read by members. Such papers shall be read by title only in case the entire program cannot be completed during four regular sessions for reading papers.

(f) Fifteen minutes shall be the maximum time allowed for the presentation of a paper.

(g) Abstracts of papers for publication in the proceedings of the Society must be handed to the Secretary-Treasurer or his representative before final adjournment of the annual meeting.

HISTORICAL REVIEW

A review of the historical antecedents of the present American Society of Zoölogists will be found in *The Anatomical Record* for January, 1917. The list of officers and meeting places of the present Society and its precursors found in the same place is brought up to date and reprinted here.

LIST OF FORMER OFFICERS

AMERICAN MORPHOLOGICAL SOCIETY

<i>President</i>	<i>Vice-President</i>	<i>Secretary-Treasurer</i>
1890—E. B. Wilson		J. P. McMurrich
1891—C. O. Whitman	E. L. Mark	J. P. McMurrich
1892—C. O. Whitman	H. F. Osborn	J. P. McMurrich
1893—C. O. Whitman	E. B. Wilson	J. P. McMurrich
1894—C. O. Whitman	W. B. Scott	G. H. Parker
1895—E. B. Wilson	W. B. Scott	G. H. Parker
1896—E. L. Mark	H. F. Osborn	G. H. Parker
1897—C. S. Minot	S. I. Smith	G. H. Parker
1898—H. F. Osborn	T. H. Morgan	G. H. Parker
1899—E. G. Conklin	W. M. Wheeler	Bashford Dean
1900—T. H. Morgan	H. C. Bumpus	J. S. Kingsley
1901—J. S. Kingsley	E. A. Andrews	T. H. Montgomery
1902—H. C. Bumpus	G. H. Parker	M. M. Metcalf

Additional Members of the Executive Committee

1891—E. B. Wilson	1897—J. S. Kingsley
H. F. Osborn	Bashford Dean
1892—E. L. Mark	1898—C. B. Davenport
T. H. Morgan	F. R. Lillie
1893—T. H. Morgan	1899—J. P. McMurrich
C. B. Davenport	G. H. Parker
1894—E. A. Andrews	1900—F. R. Lillie
F. H. Herrick	Jacob Reighard
1895—T. H. Morgan	1901—C. F. W. McClure
S. Watase	C. W. Hargitt
1896—E. G. Conklin	1902—H. S. Jennings
William Patten	R. G. Harrison

AMERICAN SOCIETY OF ZOÖLOGISTS

EASTERN BRANCH	<i>President</i>	CENTRAL BRANCH
G. H. Parker	1903	Jacob Reighard
E. A. Andrews	1904	C. H. Eigenmann
W. E. Castle	1905	F. R. Lillie
W. E. Castle	1906	C. C. Nutting
C. B. Davenport	1907	S. A. Forbes
W. M. Wheeler	1908	E. A. Birge
H. S. Jennings	1909	E. A. Birge
T. H. Montgomery	1910	C. E. McClung
H. V. Wilson	1911	George Lefevre
A. G. Mayer	1912	H. B. Ward
Raymond Pearl	1913	H. B. Ward

LIST OF FORMER OFFICERS

EASTERN BRANCH	<i>Vice-President</i>	CENTRAL BRANCH
Jacob Reighard	1903	H. F. Nachtrieb
W. E. Castle	1904	S. J. Holmes
William Patten	1905	William A. Locy
William Patten	1906	George Lefevre
F. H. Herrick	1907	H. B. Ward
H. S. Jennings	1908	M. F. Guyer
H. V. Wilson	1909	M. F. Guyer
H. H. Wilder	1910	H. F. Nachtrieb
H. E. Crampton	1911	R. H. Walcott
G. A. Drew	1912	C. M. Child
Alex. Petrunkevitch	1913	C. M. Child

Secretary-Treasurer

G. A. Drew	1903	Frank Smith
G. A. Drew	1904	F. R. Lillie
H. S. Pratt	1905	C. E. McClung
H. S. Pratt	1906	T. G. Lee
C. J. Herrick	1907	T. G. Lee
L. L. Woodruff	1908	T. G. Lee
L. L. Woodruff	1909	Charles Zeleny
H. W. Rand	1910	H. V. Neal
Raymond Pearl	1911	H. V. Neal
J. H. Gerould	1912	W. C. Curtis
Caswell Grave	1913	W. C. Curtis

Executive Committeemen

F. R. Lillie	George Lefevre
T. H. Montgomery	T. G. Lee
H. C. Bumpus	Herbert Osborn
H. S. Jennings	C. H. Eigenmann
E. A. Andrews	J. G. Needham
W. R. Coe	S. J. Holmes
G. A. Drew	W. A. Locy
M. M. Metcalf	C. M. Child
D. H. Tennent	R. H. Walcott
R. G. Harrison	W. C. Curtis
H. E. Jordan	Oscar Riddle
C. E. McClung	H. B. Ward
	Chauncey Juday
	H. W. Norris
	C. E. McClung
	H. F. Nachtrieb

AMERICAN SOCIETY OF ZOÖLOGISTS (AMALGAMATED)

<i>President</i>	<i>Vice-President</i>	<i>Executive Committeemen</i>
1914. C. E. McClung	M. F. Guyer	H. E. Jordan—1 year H. F. Nachtrieb—2 years H. V. Wilson—3 years George Lefevre—4 ydars A. F. Shull—5 years
1915. W. A. Loey	W. E. Ritter	D. H. Tennant
1916. D. H. Tennent	Charles Zeleny	R. P. Bigelow—5 years L. J. Cole—4 years
1917. M. M. Metcalf	Charles Zeleny	H. V. Wilson
1918. George Lefevre	L. L. Woodruff	M. M. Metcalf
1919. C. M. Child	H. H. Wilder	George Lefevre

Secretary-Treasurer,

1914-1918	Caswell Grave
1918-	W. C. Allee.

LIST OF PLACES OF MEETING

AMERICAN MORPHOLOGICAL SOCIETY

1890—Boston	1894—Baltimore	1899—New Haven
1891—Philadelphia	1895—Philadelphia	1900—Baltimore
1892—Princeton	1896—Boston	1901—Chicago
1893—New Haven	1897—Ithaca	1902—Washington
	1898—New York	

CENTRAL NATURALISTS

1899—Chicago	1900—Chicago
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SOCIETY OF AMERICAN ZOÖLOGISTS

1901—Chicago	1902—Washington
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AMERICAN SOCIETY OF ZOÖLOGISTS

EASTERN BRANCH	JOINT MEETINGS	CENTRAL BRANCH
1903—Philadelphia	1905—Ann Arbor	1903—St. Louis
1904—Philadelphia	1908—Baltimore	1905—(Mch.) Chicago
1906—New York	1911—Princeton	1907—(Mch.) Madison
1907—New Haven	1912—Cleveland	1907—Chicago
1909—Boston	1913—Philadelphia	1910—(Apr.) Iowa City
1910—Ithaca		1910—Minneapolis
		1912—(Apr.) Urbana

OFFICERS AND LIST OF MEMBERS¹

AMERICAN SOCIETY OF ZOÖLOGISTS (AMALGAMATED)

1914—Philadelphia	1917—Minneapolis
1915—Columbus	1918—Baltimore
1916—New York	1919—St. Louis

Officers for 1919

President.....	C. M. CHILD
Vice-President.....	H. H. WILDER
Secretary-Treasurer.....	W. C. ALLEE

Executive Committee

	<i>Term expires</i>
L. J. COLE.....	1919
R. P. BIGELOW.....	1920
H. V. WILSON.....	1921
M. M. METCALF.....	1922
GEORGE LEFEVRE.....	1923

Representatives of the Society in the Division of Biology and Agriculture of the National Research Council

	<i>Term expires</i>
F. R. LILLIE.....	1920
M. F. GUYER.....	1921
G. H. PARKER.....	1922

HONORARY MEMBER

JAMES VISCOUNT BRYCE, HINDLEAP, FOREST ROW, SUSSEX, ENGLAND

LIFE MEMBERS

- ANDREWS, ETHAN ALLEN, Ph.B. (Yale), Ph.D. (Johns Hopkins), Professor of Zoölogy, *Johns Hopkins University, Baltimore, Md.*
- DEAN BASHFORD, A.B. (College of City of New York), A.M., Ph.D. (Columbia), Professor of Vertebrate Zoölogy, Columbia University; Curator Emeritus of Fishes and Reptiles, *American Museum Natural History, Riverdale-on-Hudson, New York.*

¹ The data given in this list is based on the last preceding list published in *The Anatomical Record*, Vol. 14, No. 1, with such corrections and additions as have been sent in to the Secretary on the blanks supplied for that purpose and on the journal mailing list of The Wistar Institute. Please notify the Secretary of errors in this copy of the membership list that they may be corrected in the next published list.

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- ACKERT, JAMES EDWARD, A.B., A.M., Ph.D. (University of Illinois), Assistant Professor of Zoölogy, Parasitologist Agr. Exp. Station; *Kansas State Agricultural College, Manhattan, Kan.*
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